INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭ'lo
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'ĭ
10^{-2}	centi	c	sĕn'tĭ
10^{-3}	milli	m	mĭl'ĭ
10^{-6}	micro	μ	mī'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

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RADIATION DATA AND REPORTS

Volume 14, Number 1, January 1973

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

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U.S. ENVIRONMENTAL PROTECTION AGENCY

William D. Ruckelshaus, Administrator

Reports

Technology Assessment of Risk Reduction Effectiveness of Waste Treatment Systems for Light-Water Reactors

James E. Martin, Floyd L. Galpin, and Ted W. Fowler[1]

The Environmental Protection Agency (EPA) routinely performs technology assessment of applications of nuclear energy that have the potential to introduce radioactive material into the environment. The Agency has extensively examined the performance of waste treatment systems for light water power reactors as a function of cost with regard to an examination of bases for environmental radiation standards and for EPA review of environmental impact statements for such plants. It was determined that significant and cost effective offsite dose reductions from gaseous discharges could be brought about by using available technology to hold up the gases until essentially krypton-85 remained; further dose reductions by cryogenic removal of krypton-85 did not appear to be justified in view of the costs involved. Similarly for liquid wastes, reasonable technology appears to stop just short of recycling waste streams to contain tritium.

The Environmental Protection Agency (EPA) considers the environmental impact of nuclear power facilities within two major activities; (1) the development of environmental radiation standards, and (2) making public comments on environmental impact statements submitted on such facilities relative to the National Environmental Policy Act. A major consideration in the assessment programs supporting these activities is the design and use of waste treatment systems to process radioactive materials prior to their discharge to the environment. The potential amount of such materials that may be released is usually determined by fuel cladding performance; the actual quantities discharged to the atmosphere or receiving waters are by and large determined by the amount of waste treatment prior to discharge. Although the greatest reduction in population dose would obviously be associated with complete removal of radionuclides from discharge effluents, it is apparent that a point of practicality is reached beyond which the degree of dose reduction achieved is not justified by the cost of the system required. The purposes of this paper are to analyze dose reductions that are obtained by the design or operation of augmented waste treatment systems and to present a general analysis of some of the known costs involved in achieving these reductions.

The EPA used several sources of information in its analysis of the performance and costs of waste treatment technology. Data which characterize the quantity and types of radionuclides discharged were derived from selected safety analysis reports and environmental reports submitted by applicants for licenses for nuclear power stations. These design and environmental reports have been reviewed in considerable detail relative to public health and environmental effects by EPA and its predecessor organization for several years. The source term characteristics of both boiling water reactors (BWR) and pressurized water reactors (PWR) were independently confirmed by field studies carried out at operating facilities. These field studies were also used as a basis for estimated doses to offsite populations on the basis of measurements of the significant pathways of exposure.

Waste treatment effectiveness

Expected dose rates from both PWR's and

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BWR's were conservatively considered on the basis of the radioactive waste discharges projected by the major reactor vendors because of fuel failures. Both the liquid and gas waste treatment systems are designed to process the wastes expected to be generated when these fuel failure conditions exist. Gas waste treatment systems depend on physically capturing and storing gaseous radionuclides to allow them to undergo radioactive decay to concentrations such that, once they are vented to the atmosphere for dispersal, offsite doses will be well below established guidelines. The method of retention varies with reactor type, the volume of gas to be processed, and the required holdup period. Liquid waste systems depend on methodology to filter, demineralize, and solidify radioactive materials out of process streams that may eventually be discharged to the aquatic environment.

Gases from pressurized water reactors (PWR)

Current PWR's handle small volumes of radioactive gases; therefore, a system of tank storage for 30–90 days decay is used, with subsequent discharge through a building vent. Table 1 illustrates a design source term typical of a 1,100 megawatt (electric) [MW(e)] PWR (*1*) and the effectiveness of increasing holdup to reduce all components of the gas mixture except krypton–85. The capacity of systems for

Table 1. Typical 1,100 MW(e) PWR source term [a] (1 percent failed fuel)

Days decay	Radionuclides (Ci/year)			
	Krypton-85	Xenon-131m	Xenon-133	Other gases
7	11,900	6,000	390,000	<600
15	11,900	3,800	140,000	<50
30	11,900	1,600	20,000	<1
45	11,900	600	2,700	0
60	11,800	300	400	0
90	11,700	50	10	0

[a] Based on average of discharges estimated in safety analysis reports for the North Anna, Palisades, and Arkansas Nuclear One—Unit 2 plants.

most PWR's is sufficient to provide 60 days holdup; with this decay period, discharges are almost solely krypton–85, a low-energy beta emitter with minimal dosimetric significance for normal operating conditions as well as assumed design conditions leading to maximum routine releases. Using design data for several proposed PWR plants which assumed 1 percent failed fuel, the maximum estimated offsite dose rates as shown in table 2 from a typical 1,100 MW(e) plant were 20, 4.3, 2.0, and 1.6 mrem/year for holdup times of 15, 30, 45 and 60 days, respectively. These same data, expressed as the

Table 2. Typical offsite whole-body dose rates for a 1,100 MW(e) PWR with 1 percent failed fuel (from gaseous emissions)

Days holdup	mrem/year	Dose reduction factor
0	180	1
15	20	9
30	4	45
45	2	90
60	1.6	110
90	1.5	120

ratio of the dose rate at zero holdup to the reduced dose rate after holdup, are plotted in figure 1 as a function of holdup time. The curve in figure 1 begins to flatten around 45 days, indicating that exposures to individuals at the site boundary decrease only slightly for longer

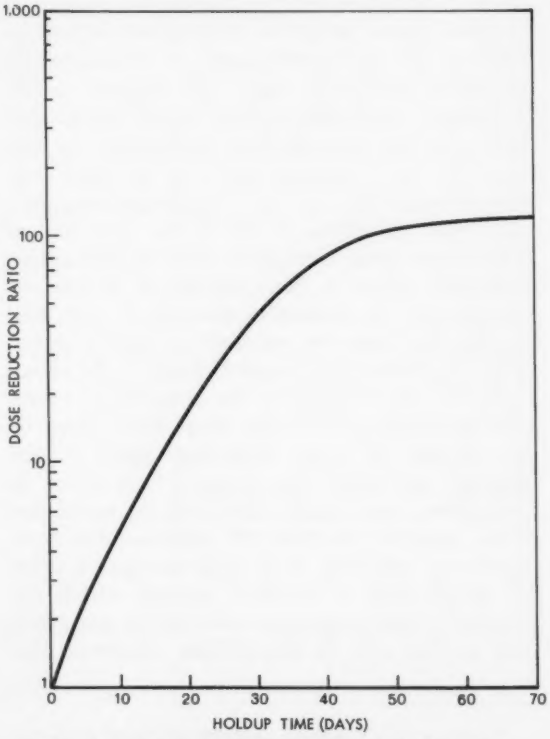

Figure 1. Dose reduction factor vs. holdup time for a "typical" PWR

holdup periods. Since krypton–85 has a 10.76 year half-life, use of holdup tanks beyond 45–60 days has little further effect in reducing the dose rate. On the other hand, the resulting radiological effects associated with the small quantities of this beta emitter will be negligible. Further reduction could only be achieved by removing the krypton–85 from the off-gas stream.

The above data, which are for a typical PWR, appear to be conservative when compared to actual estimates being made for new generation PWR plants. For example, discharge estimates for the Surry Nuclear Power Station (*2*) which are presented in table 3 (adjusted to 1 percent failed fuel) indicate that both discharges and offsite dose rates could be about one-fourth those determined for the typical plant selected. It is perhaps significant that these low dose rates pertain to achievable reductions by holdup of gases in the main gas processing system. Relatively speaking, therefore, once the primary source has been processed, the secondary gaseous sources, such as turbine building exhaust, general ventilation, etc., may well become the predominant source of offsite dose from PWR's.

Gases from boiling-water reactors

Until recently, a BWR waste treatment system of typical design handled large volumes of radioactive gases by delaying them for about 30 minutes and discharging them through a tall stack (about 100 meters) to the atmosphere. Current reactor license applications indicate that several systems have recently become available to provide longer holdup periods with discharge usually through a building vent rather than a stack. Systems which have been proposed to obtain this holdup (*3*) and the resulting dose reductions usually include catalytic recombiners (to reduce gas volume) followed by either: (1) low temperature or cryogenic adsorption on charcoal; (2) gas storage under pressure; or (3) in some cases, cryogenic distillation. Although not all systems have been operated in full-scale BWR's, EPA consultations with various vendors of gaseous waste management systems indicate that such systems can reduce quantities of radioactive materials in gaseous emissions from BWR's such that resulting exposures to individuals in the general environment are low. Using estimated discharge data for typical 1,000 MW(e) boiling-water power reactors, for example, it has been estimated that discharge of the effluent from a building vent after 25 days holdup would produce a maximum dose rate offsite of about 6 mrem/year; for 45 and 60 days, the dose rate would be about 0.7 and 0.3 mrem/year, respectively, mostly from krypton–85. These data are shown in table 4 and are plotted as dose reduction factors in figure 2. If the effluents are discharged through a stack instead of a vent following such holdup periods, expected dose rates would be about 0.1, 0.01, and 0.005 mrem/year, respectively.

It appears from discussions with industry that the most common holdup systems from the standpoint of size, design, performance, and cost using charcoal adsorption are for holdup periods of about 25–30 days with discharge of the processed effluent through a building vent.

Table 3. Estimated offsite dose rates for one unit of the Surry (PWR) Nuclear power station at 822 MW(e) with 1 percent failed fuel [a]

Days holdup	Annual gaseous discharge rates (Ci/year)				Offsite dose (mrem/year)[b]
	Krypton-85	Xenon-131m	Xenon-133	Total	
15	2,910	1,400	77,200	81,500	10.7
30	2,900	582	10,700	14,200	1.86
45	2,890	242	1,500	4,630	.60
60	2,809	100	208	3,190	.42
90	2,870	17	4	2,890	.38

[a] Data presented in Surry Environmental Impact Statement (*2*) were for 0.25 percent failed fuel; adjusted to 1 percent for this table. Data are for gas processing systems only and do not consider secondary gaseous releases.

[b] Based on dispersion factor of 2.5×10^{-6} s/m^3 and the weighted mixture of gaseous radionuclides in the table.

Table 4. Estimated offsite dose rate (mrem/year) from gaseous emissions for typical 1,000 MW(e) BWR [a]

Holdup period	100 m stack discharge	Vent discharge
30 minutes	500	—
1 day	8	420
3 days	2.0	110
9 days	.8	45
25 days	.1	6
45 days	.01	.7
60 days	.005	.3

[a] Data normalized to source term which after 30 minutes decay would yield 500 mrem/year at typical site boundary.

These conditions would result in maximum offsite individual exposure of about 6 mrem/year for the upper design assumptions of leaking fuel. Discharge of the processed effluent through a stack after 25–30 days holdup would give a further reduction in dose to about 0.1 mrem/year at substantial increment of cost. Any given exposure rate criterion can be met by shorter holdup periods if a stack is used because of the additional dilution obtained between the points of discharge and exposure. Although the same maximum dose rate would result by substituting a stack for increased holdup capacity, a higher man-rem dose might occur from dispersing a larger amount of radioactivity into the atmosphere.

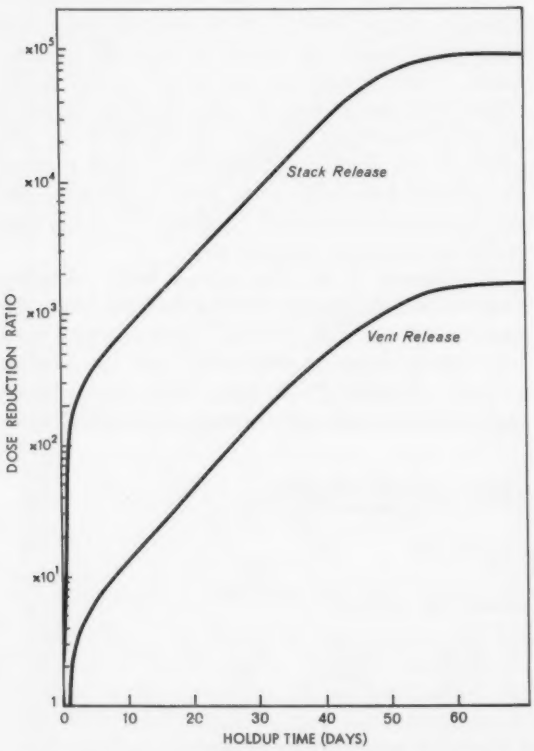

Figure 2. Dose reduction ratio vs. holdup time for gaseous emissions from a "typical" 1,000 MW(e) BWR

Cost effectiveness of treatment systems—liquid wastes

Treatment of liquid wastes for both PWR's and BWR's depends on the same general techniques of filtration, demineralization, and solidification by evaporation or other means so that the majority of the radioactive material is removed from process streams and disposed of as solid wastes by shipment offsite to licensed burial facilities. Most facilities already incorporate designs that allow subsequent dose rates to individuals of 1 mrem/year or less to be achieved, even allowing for discharges of tritium. Increased costs may be required to upgrade some reactor systems currently operating in order to reach these levels of exposure, but such costs would be within a range that numerous utilities have already accepted as commercially feasible by installing such equipment. EPA field studies conducted to date at both operating PWR's (*4*) and BWR's (*5*) confirm that population exposures from liquid waste discharges are relatively small in comparison to gaseous discharges, and are virtually impossible to determine in the general environment.

PWR gaseous waste treatment

Current gaseous waste treatment system designs for PWR's are, by and large, able to provide sufficient holdup (about 60 days) to reduce discharges to essentially krypton–85; therefore, no substantial incremental costs above those already being expended would be required for PWR's to meet this criterion. The only dose reductions that could be achieved by additional expenditures for PWR's would be to remove krypton–85 from the offgas streams by the use of cryogenic techniques or a combination of charcoal and cryogenic delay beds. The only dose reduction possible above that achieved with holdup systems of 60–90 days capacity is about 1.5 millirems per year for the 1 percent

Table 5. Cost effectiveness of PWR gaseous waste treatment systems in reducing annual dose rate

Dose data		Recombiner and holdup tanks			Recombiner plus cryogenic		
Days holdup	Annual dose (mrem)	Capital cost ($10³)	Annual cost[a] ($10³)	Δ$ / Δmrem	Capital cost ($10³)	Annual cost ($10³)	Δ$ / Δmrem
0	181	0	0	—	0	0	
1	152	[b]400	60	2,100	400	[c]60	2,100
15	20	500	74	105	—	—	—
30	4.3	600	88	810	—	—	—
45	2.0	700	102	6,100	—	—	—
60	1.6	800	116	35,000	—	—	—
90	1.5	900	130	140,000	—	—	—
∞	0	—	—	—	1,000	[c]213	1,000

[a] Includes $25,000 annual operating cost for basic system; incremental annual cost of $5,000 assumed for each 15 days holdup added above recombiner. Based on 8 percent interest on capital cost.
[b] Costs for recombiner and holdup based on the Sequoyah Nuclear Power Station (6).
[c] Includes estimated annual operating costs of $100,000.

failed fuel situation in a 1,100 MW(e) reactor. The actual increment of dose reduction possible for most routine operations with good fuel performance is considerably less than 1.5 millirems per year. In essence, therefore, two options are available for gaseous waste treatment from PWR's: (1) holdup tanks (current design) to reduce discharges to krypton–85, and (2) recombiners followed by a cryogenic system (no tanks) to remove all noble gases for long-term storage. Relative costs of using each of these options in a typical 1,100 MW(e) plant, inclusive of operational costs, are shown in table 5. The data indicate that the annualized cost of complete removal of krypton–85 by cryogenic techniques is almost twice that of providing 45–60 days decay with holdup tanks.

Figure 3 is a plot of the data in table 5 for the tank treatment option; it illustrates that about 15 days holdup is the most cost effective provision of holdup capacity. Figure 3 also indicates that significant dose reductions versus cost are obtainable up to about 30–45 days, after which rapidly increasing costs would be incurred for small reductions in dose. This situation exists because essentially all of the remaining gas is krypton–85. The dose represented by this residual krypton–85 is only about 1.5 millirems per year for a typical PWR. The value or necessity for such a dose reduction is questionable since the computed dose represents a surface dose to the skin, not to viable tissue or genetically significant organs. Since krypton–85 is essentially a low energy emitter, the dose to the living layers of the skin would be approximately half the surface dose, and the genetic

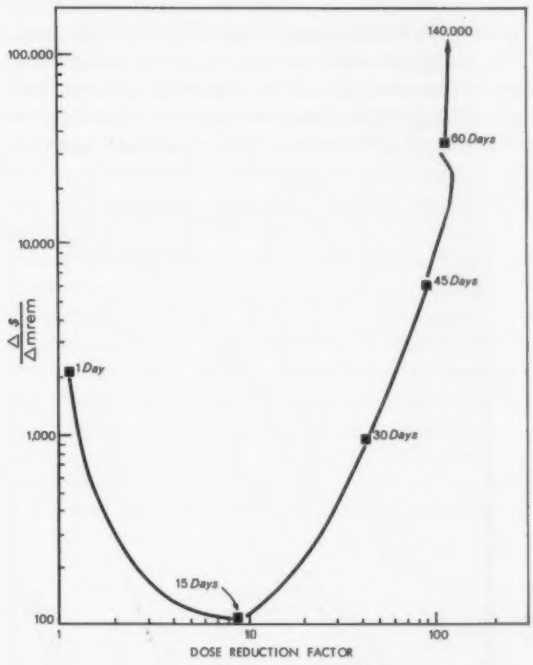

Figure 3. Cost effectiveness of PWR gaseous waste treatment (recombiner and holdup tanks)

dose would be approximately 2.5 percent of the skin surface dose (7).

BWR gaseous waste treatment

The cost of gaseous waste treatment for BWR's is a bit more complex than for PWR's,

primarily because most system designs for long holdup periods are relatively new with little actual experience on design, construction, and operating costs. Estimates of system costs are based on contractual work (*8*) and vendor discussions and are shown in figure 4. It appears from a number of recent environmental reports filed by utilities in support of license applications for BWR's that systems based on charcoal absorption beds may be retrofitted at a cost of about three to four million dollars for a 1,000 MW(e) plant (GE data in figure 4). This system could provide dose reduction factors of 100 to 1,000 above those currently available with delay lines and a stack. Cryogenic techniques can also be used to entrap the noble gases with subsequent storage for long periods. The installed cost of this system should be somewhat similar to the charcoal system, but the accompanying dose reduction factor may be a factor of 10 higher. The cryogenic systems apparently are not yet fully evaluated relative to potential system leakage and the redundancy that would be required for plants using them to be licensed. This lack of performance information is apparently the major reason that only a few of these have been proposed for BWR facilities.

The cost effectiveness of reducing potential annual offsite dose rates for a typical BWR is shown in figure 5 for three of the options that currently appear to be available to reactor designers. The first option is to add a catalytic recombiner and charcoal beds onto a system employing a 30-minute delay-line and a stack, a common retrofit situation for BWR's in operation or nearing completion. The second option would be to add a recombiner and charcoal beds to a system with a 30-minute delay-line and a building vent discharge. A third option which is available early in design would be to eliminate both the 30-minute delay-line and the stack and use only recombiners, charcoal beds, and vent discharge. If the design objective for

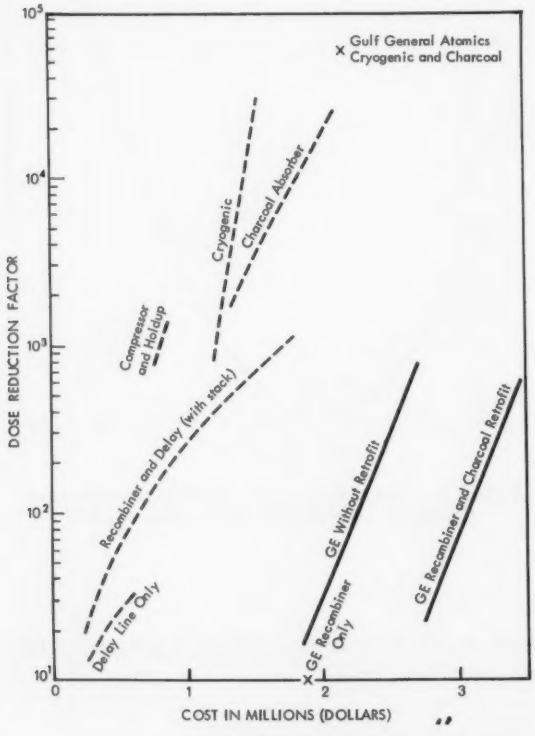

Figure 4. Cost of dose reduction for gaseous effluents at a BWR

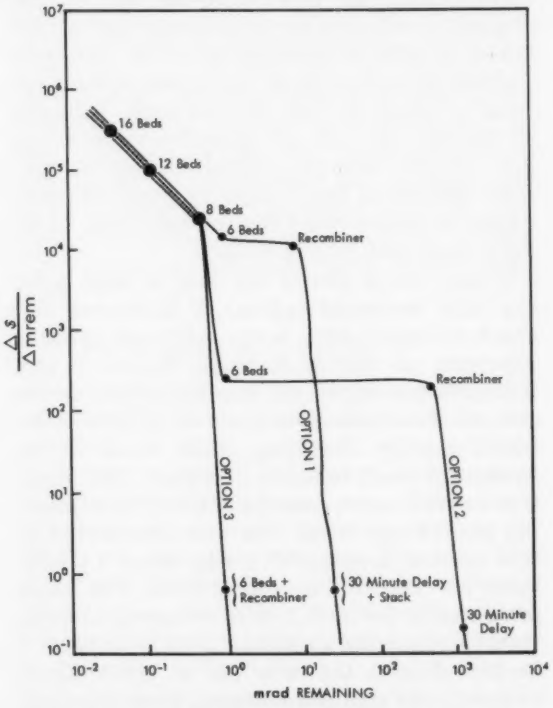

Figure 5. Cost effectiveness of adding various gas treatment components to achieve annual dose reduction to individuals offsite for a "typical" 1,000 MW(e) BWR

BWR's were to reduce potential offsite dose rates to less than 10 mrem/year, option 3 would be the most cost-effective approach. The cost data used in determining the cost effectiveness curves were obtained primarily from environmental reports for selected BWR power plants and are believed to reasonably reflect industry costs for such systems for BWR's.

Conclusions

On the basis of the foregoing analysis, it can be concluded that a typical 1,100 MW(e) PWR can normally be expected to operate such that dose rates for individuals at the maximum point offsite would be somewhere below about 1.5 mrem/year with systems currently being installed by the industry for liquid or gaseous waste treatment. Similarly, a BWR can be expected to operate so that exposures at the maximum point offsite would be less than about 6 mrem/year if gas holdup treatment equipment costing about three to four million dollars is retrofitted in the design. Further reductions in this dose for a BWR would require longer holdup periods (greater than 25–30 days) resulting in costs on the order of one-half million dollars per millirem reduced. Complete removal of krypton–85 from either PWR's or BWR's could cost from one-quarter to one million dollars per plant for exposure reductions in most cases of about 1 mrem/year or less. These estimated individual exposures offsite are dependent on the assumption that all systems are operational at all times. Failure rates or down times of such waste treatment systems are not generally known, but any technical conclusions relative to expected population dose rates from light-water reactors should consider that such systems would occasionally be out of service. It should also be noted that individual offsite dose rates presented in this paper are only doses attributable to the major gaseous radioactive waste treatment system. Secondary gas sources, such as containment purging, will add to the dose rates estimated for effluents from the waste treatment system.

Having once reduced gaseous effluents of light-water reactors to essentially krypton–85, the only further treatment that can be considered would be to remove the krypton–85 from the effluent and store it in pressurized tanks or cylinders for about 100 years to allow it to decay. Whether it is worth while or even desirable to exert further effort to contain the residual krypton–85 is doubtful at the present time. For most normal operating conditions, an expenditure of one-quarter to one million dollars is required for systems which would prevent less than 100 curies per year of krypton–85 from being discharged to the atmosphere, a relatively small quantity of radioactive material and generally negligible from an environmental or public health impact standpoint. This may be considered an unnecessarily drastic step for nuclear reactors since the major source of krypton–85 is that discharged from reactor fuel reprocessing facilities. Discharges at these facilities are several thousand curies per day; therefore, if reductions of krypton–85 are required from a public health standpoint, reductions of discharges to the atmosphere should first be made at these facilities. The Environmental Protection Agency has made such a recommendation in reviews of environmental impact statements for fuel reprocessing plants and the Atomic Energy Commission is conducting studies of systems to cope with this potential problem. Furthermore, the potential hazards associated with retaining cylinders of krypton–85 and methods for ultimate storage for about 100 years require further evaluation.

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Assessment of Thyroid Inhalation Doses in the Western United States From the Chinese Nuclear Test of November 1971

R. B. Evans, R. N. Snelling, and F. N. Buck [1]

Following a nuclear detonation by the People's Republic of China, measurable increases of radioactivity were detected over the western United States by the Air Surveillance Network which is operated by the National Environmental Research Center-Las Vegas. The progress and intensity of the radioactive cloud across the United States are presented graphically. The highest hypothetical infant thyroid dose equivalent calculated to result from the inhalation of iodine-131 and tellurium-132 was 0.2 mrem at Scotty's Junction, Nev.

The U.S. Atomic Energy Commission announced that the People's Republic of China detonated a nuclear device with a yield of about 20 kilotons in the atmosphere in the vicinity of its Lop Nor testing ground at 1:00 a.m., e.s.t., on November 18, 1971. Measurable increases in airborne radioactivity were subsequently detected over the continental United States by the Air Surveillance Network (ASN) beginning with samples collected on November 24, 1971 (*1*). The network, operated by the National Environmental Research Center-Las Vegas (NERC–LV), presently includes air sampling stations in 21 western States.[2] During November 1971, 103 ASN stations operated continuously. Gross beta concentrations ranging from 0.3 pCi/m^3 to 2.0 pCi/m^3 above background were first observed in Washington and Oregon, although the highest gross beta concentrations were ultimately found in samples from western Nevada and eastern California. The highest hypothetical infant thyroid dose equivalent resulting from inhalation of iodine–131 and tellurium–132 was slightly more than 0.2 mrem at Scotty's Junction, Nev., which is approximately 125 miles northwest of Las Vegas, Nev. (*2*). The Federal Radiation Council has recommended that the average radiation dose to the thyroids of a suitable sample of the general population be kept below 500 mrem per year. The value of 0.2 mrem calculated for Scotty's Junction is less than one-tenth of 1 percent of this radiation protection guide (*3*).

Gross beta concentrations in air

Twelve sampling stations were selected at random for a determination of background concentrations of gross beta radioactivity. The average gross beta concentrations and standard deviation were determined for the first 23 days of November. Values less than the minimum detectable concentration were ignored in this computation, thus raising the estimate of the average. The average gross beta concentration, i.e., background concentration, was found to be 0.15 pCi/m^3 with an average standard deviation of 0.06 pCi/m^3. For the purposes of detecting airborne radioactivity, values greater than 3 standard deviations above background (i.e., greater than 0.33 pCi/m^3) were considered to be significant. Because results are reported to the nearest 0.1 pCi/m^3, a gross beta concentration equal to or greater than 0.4 pCi/m^3 was assumed to represent a departure from background.

Utilizing the Way-Wigner equation for long-lived gross beta activity in air, an estimate of the apparent fission product age was determined (*4*). Analysis of 10 randomly selected air filters indicated a time of formation not inconsistent with a November 18 detonation date.

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[1] National Environmental Research Center-Las Vegas, U.S. Environmental Protection Agency, Las Vegas, Nev. At the time this work was performed, the Center was named the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding No. AT(26–1)–539 with the Nevada Operations Office, U.S. Atomic Energy Commission. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Figure 1. Air surveillance network stations with gross beta concentrations above background, in samples collected during a 24-hour period ending November 26, 1971, 1200 local standard time

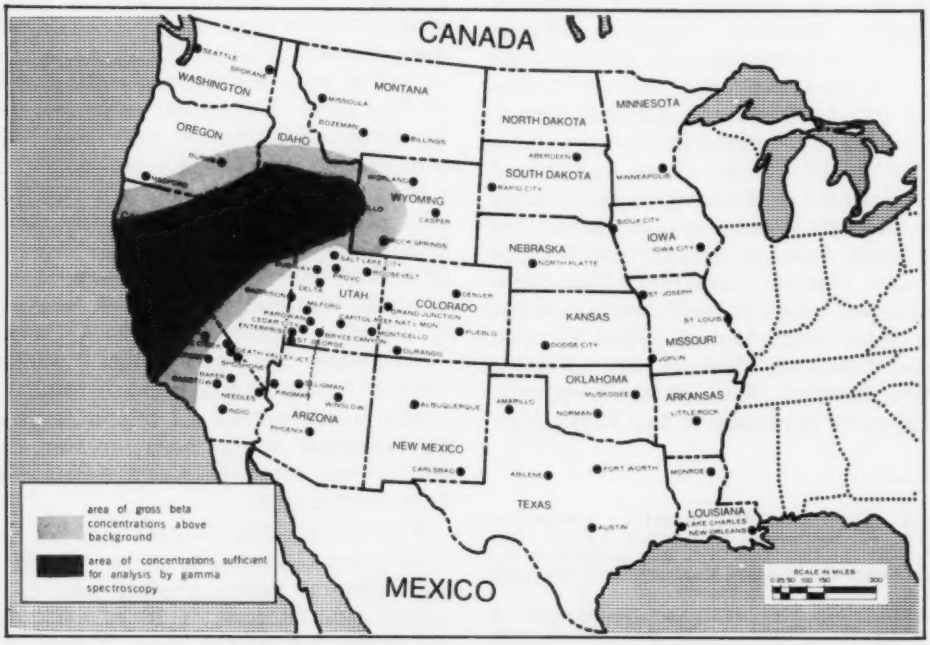


Figure 2. Air surveillance network stations with gross beta concentrations above background, in samples collected during a 24-hour period ending November 25, 1971, 1200 local standard time

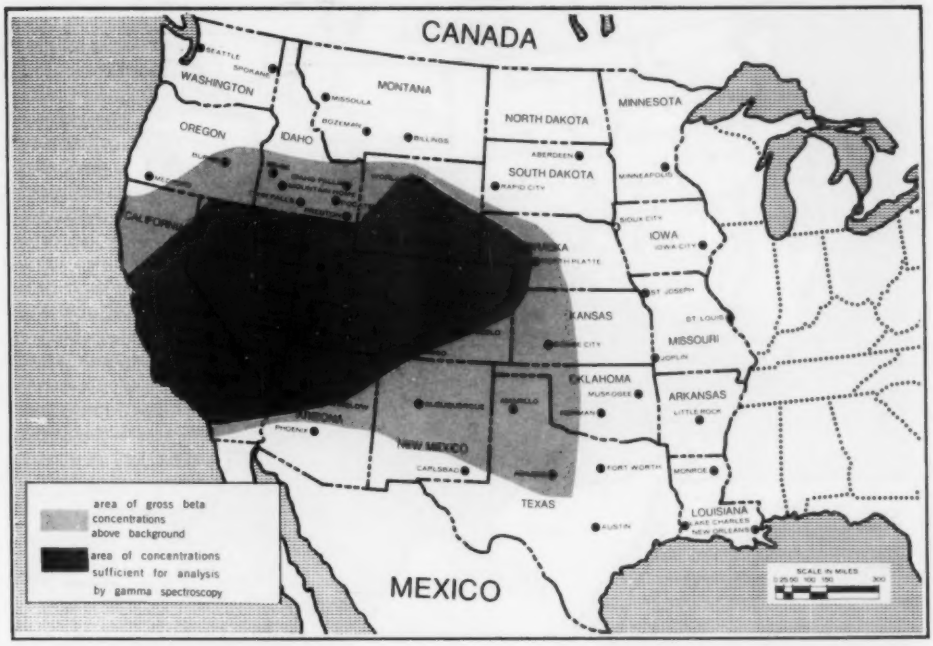


Figure 3. Air surveillance network stations with gross beta concentrations above background, in samples collected during a 24-hour period ending November 26, 1971, 1200 local standard time

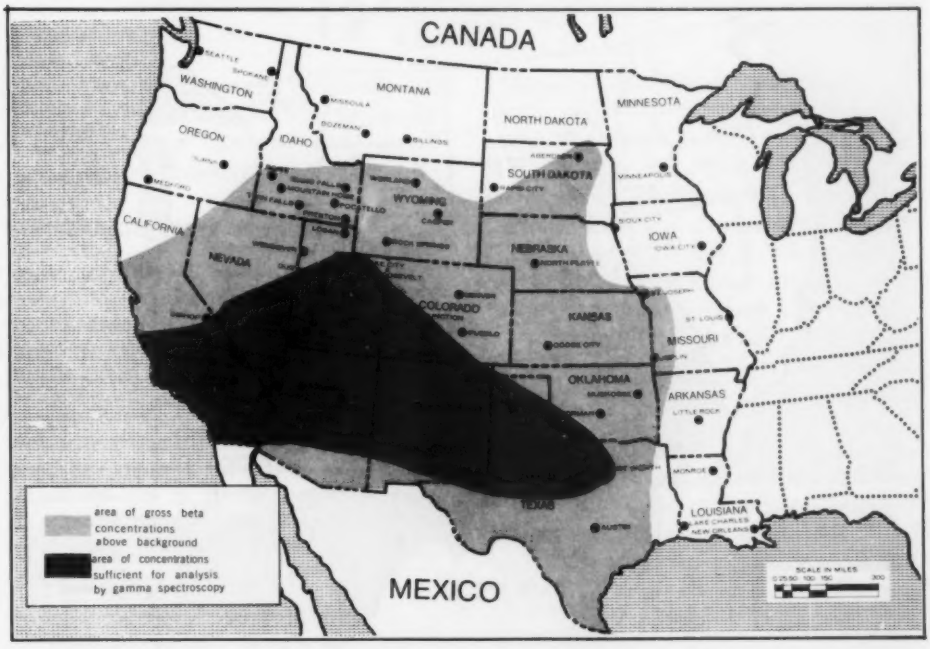
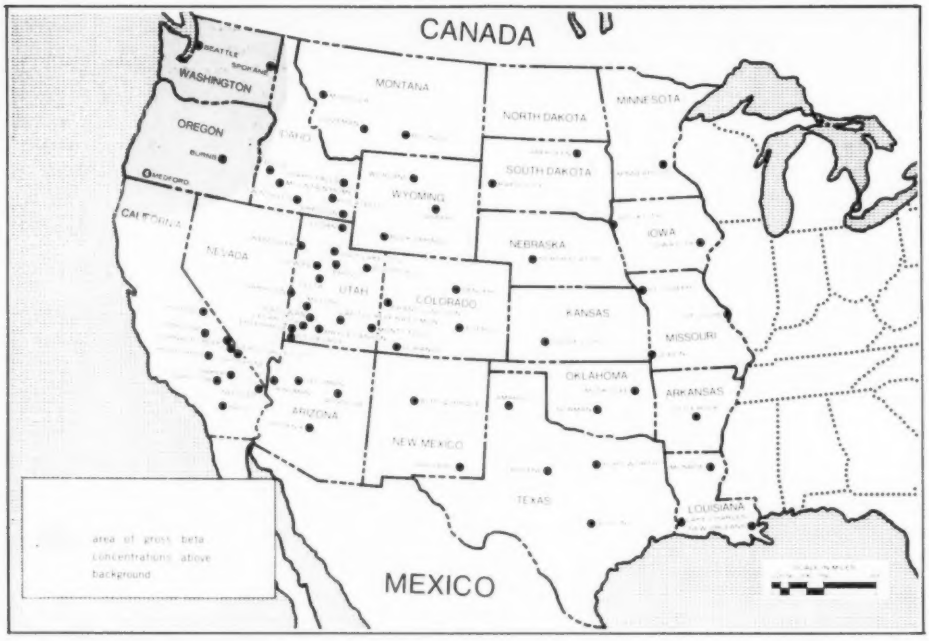


Figure 4. Air surveillance network stations with gross beta concentrations above background, in samples collected during a 24-hour period ending November 27, 1971, 1200 local standard time



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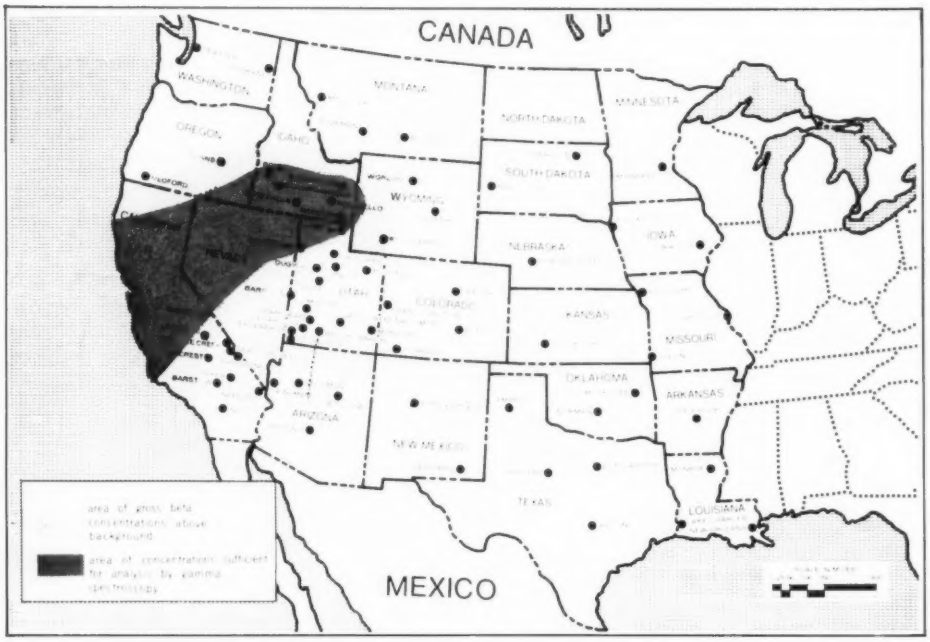

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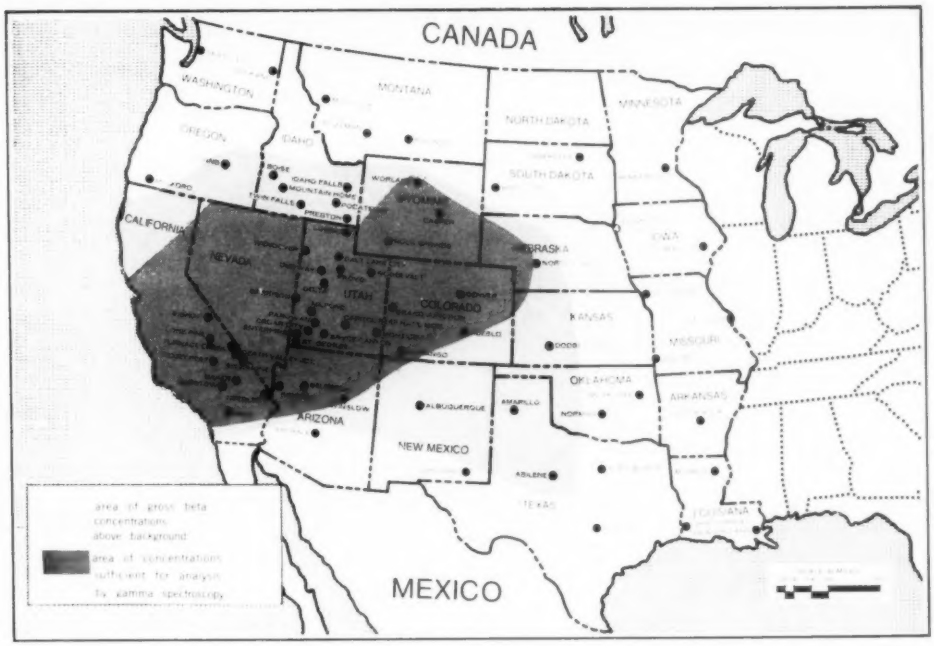

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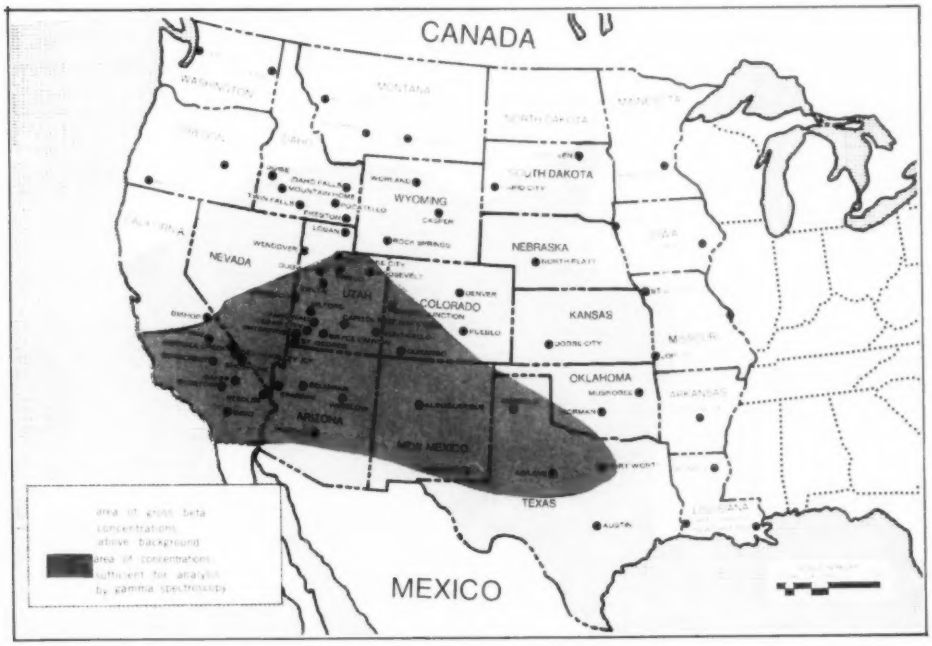

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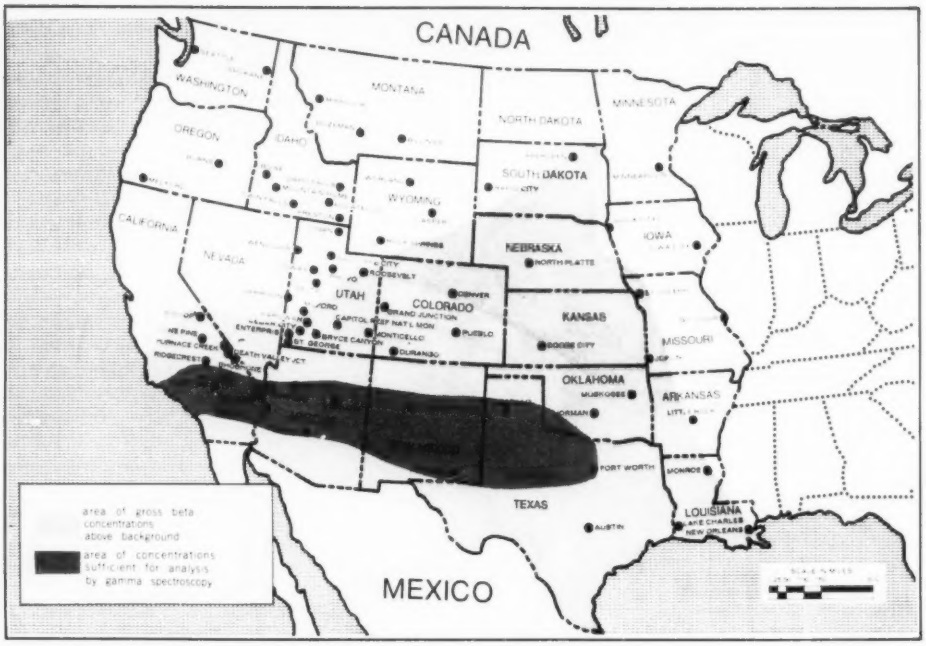


Figure 5. Air surveillance network stations with gross beta concentrations above background, in samples collected during a 24-hour period ending November 28, 1971, 1200 local standard time

Figure 6. Air surveillance network stations with gross beta concentrations above background, in samples collected during a 24-hour period ending November 29, 1971, 1200 local standard time

Figure 7. Air surveillance network stations with gross beta concentrations above background, in samples collected during a 24-hour period ending November 30, 1971, 1200 local standard time

Gross beta air sampling results for successive days are plotted in figures 1 through 7. By December 1, gross beta concentrations at all stations had dropped to background.

Composition of airborne radioactivity

Gross beta concentrations above background were measurable at 95 routine ASN stations. A total of 83 stations showed concentrations high enough to allow quantitation of specific radionuclides by gamma spectroscopy. Radionuclides quantitated included cerium-141, barium-140, tellurium-132, and iodine-131. The highest single gross beta concentration was 51 pCi/m^3 observed on a prefilter collected at Fallon, Nev., on November 25. Analysis of this sample by gamma spectroscopy showed radionuclide concentrations as follows:

Iodine-131 = 2.0 pCi/m^3
Cerium-141 = .9 pCi/m^3
Barium-140 = 2.6 pCi/m^3
Tellurium-132 = 1.6 pCi/m^3

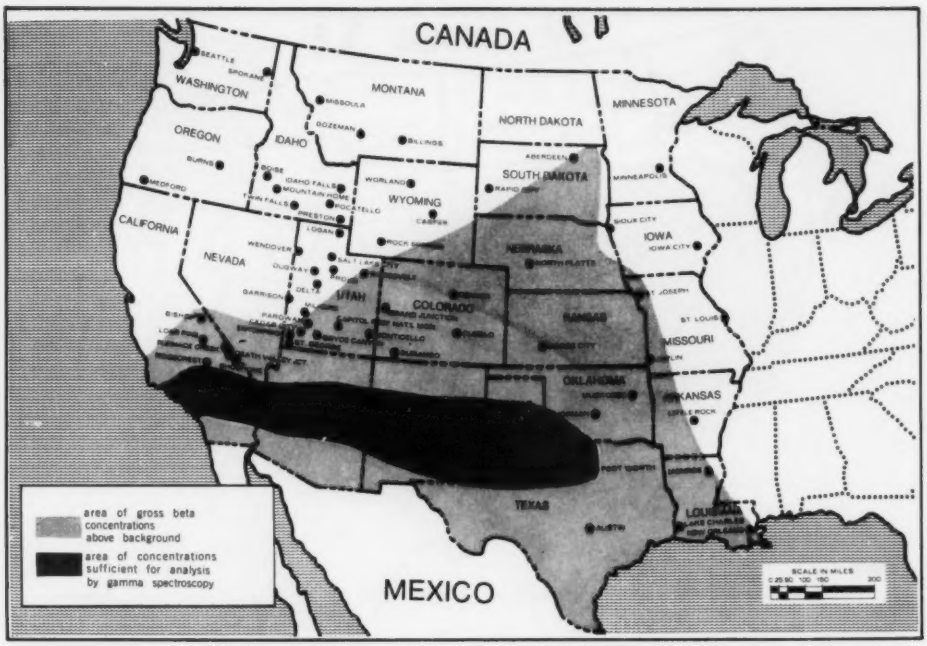
Uranium-237 was also present on the air filters analyzed in quantities approximately equal to that of barium-140. Additional trace radionuclides identified but not quantitated included molybdenum-99, zirconium-95, ruthenium-103, and neodymium-147.

Of the above radionuclides, only iodine-131 and tellurium-132 were considered to contribute to the hypothetical infant thyroid dose equivalents represented by figures 8 and 9. Hypothetical doses from other radionuclides were much smaller than the thyroid dose and were neglected.

Analysis of activated charcoal cartridges (secondary to the particulate filters) from 25 routine air sampling stations indicated that the airborne radioactivity was particulate in nature with little or no detectable gaseous radioiodine.

Hypothetical thyroid inhalation dose equivalents

Hypothetical thyroid dose equivalents corresponding to inhalation of airborne radio-



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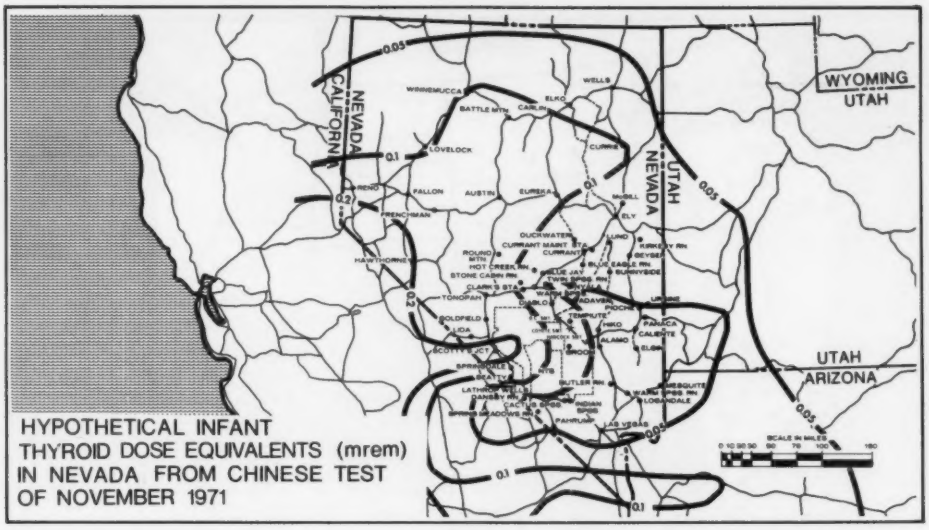

Figure 8. Hypothetical infant thyroid dose equivalents (mrem) in Nevada from the Chinese test of November 1971

Figure 9. Hypothetical infant thyroid dose equivalents (mrem) in the Western United States from the Chinese test of November 1971

activity were computed using measured time-integrated concentrations of iodine-131 and tellurium-132, and the following dose conversion factors:

Radionuclide	Dose conversion factor $\left(\frac{\text{mrem}}{\mu\text{Ci-s/m}^3}\right)$
Iodine-131	0.59
Tellurium-132	.12

These dose conversion factors were derived using the models and standard man assumptions of ICRP Publications 2 and 10 (*5*, *6*), an assumed thyroid weight for a 1-year-old infant of 2 grams (*7*), and an assumed infant breathing rate of 4.7 m^3/day (*8*). The dose from tellurium-132 was considered to result from uptake of the daughter iodine-132 into the blood stream and subsequently into the thyroid as described in ICRP 10. The computations are hypothetical in the sense that the critical receptor (a 1-year-old infant) was assumed to be present and continuously exposed to the airborne radioactivity at each location, whether or not this was actually the case.

Figures 8 and 9 show ASN sampling stations and the isodose patterns for hypothetical infant thyroid dose equivalents in Nevada and in the western United States, respectively. All locations identified by name on these two figures have ASN stations. The highest calculated infant dose equivalent, slightly more than 0.2 mrem, occurred at Scotty's Junction, Nev. The hypothetical adult dose equivalent at that location was approximately 0.1 mrem. Adult dose equivalents, calculated on the basis of a 20-gram thyroid weight and a breathing rate of 22.8 m^3/day (*8*), were approximately half of the levels shown in figures 8 and 9.

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(*2*) WESTERN ENVIRONMENTAL RESEARCH LABORATORY. Special thyroid inhalation dose report, NERC–LV. (November 1971).

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington-ton, D.C. 20402 (September 1961).

(*4*) WAY, K. and E. P. WIGNER. The rate of decay of fission products. Phys. Rev. 731318–1330 (June 1948).

(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Report of ICRP Committee II on permissible dose for internal radiation, ICRP Publication 2. Pergamon Press, New York, N.Y. (1959).

(*6*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendations of the International Commission on Radiological Protection, ICRP Publication 10. A report of Committee IV on evaluation of radiation doses to body tissues from internal contamination due to occupational exposure. Pergamon Press, New York, N.Y. (1968).

(*7*) BRYANT, P. M. Data for assessments concerning controlled and accidental releases of ^{131}I and ^{137}Cs to the atmosphere. Health Phys 17:51 (July 1969).

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SECTION I. MILK AND FOOD

Milk Surveillance, September 1972

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentration and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations
Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radio-

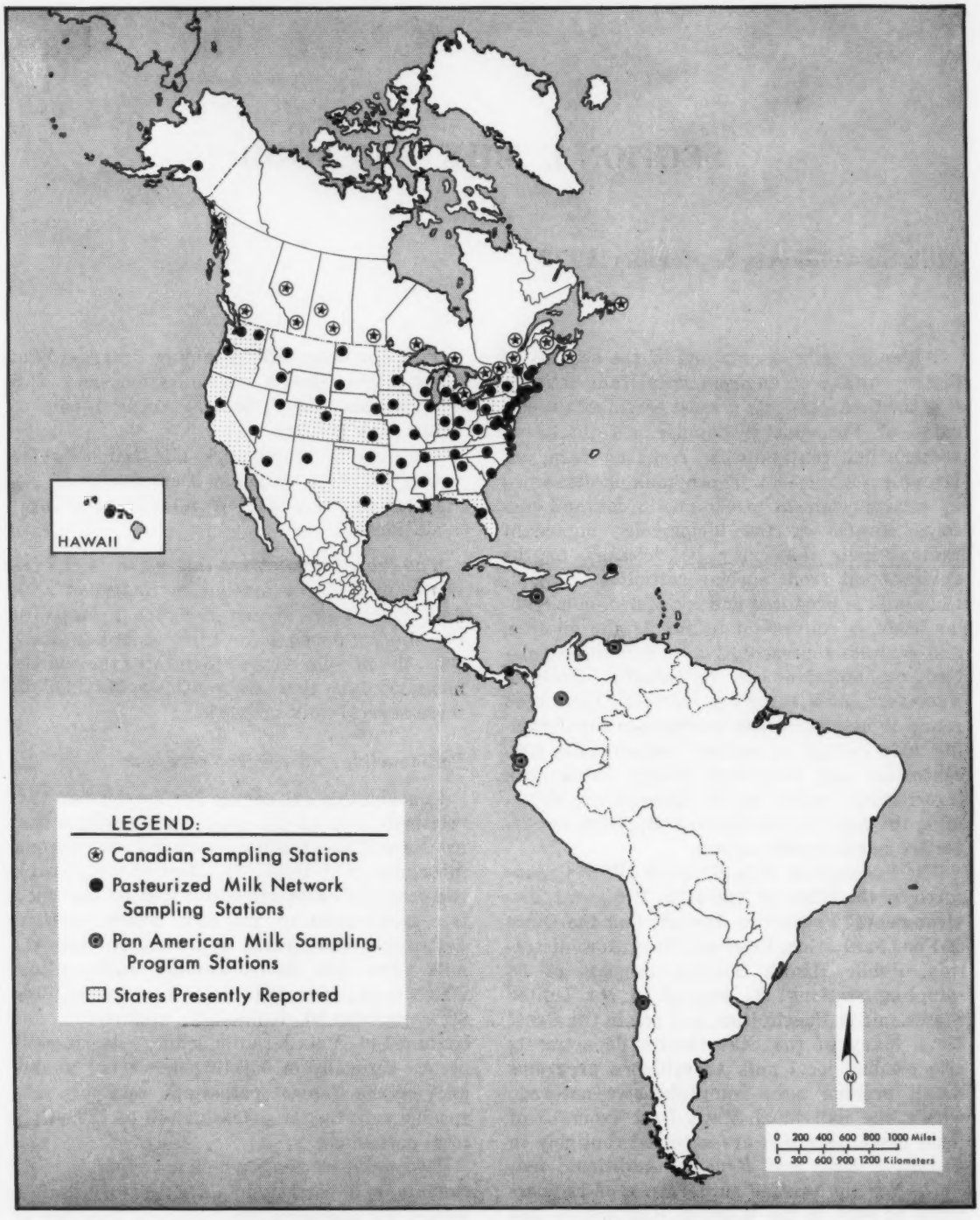

Figure 1. Milk sampling networks in the Western Hemisphere

strontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963-March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during July 1971 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. Considerable improvement has been made in the accuracy of the analyses of all radionuclides compared to the results of previous studies. Some improvement is still needed in the technique for determining the strontium-90 results. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total	
Iodine-131 (69 pCi/liter)	13 (100%)	0	0	13	6
Cesium-137 (52 pCi/liter)	12 (92%)	1 (8%)	0	13	6
Strontium-89 (31 pCi/liter)	9 (90%)	1 (10%)	0	10	6
Strontium-90 (41.6 pCi/liter)	9 (69%)	1 (8%)	3 (23%)	13	2.4

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131, Cesium-137, Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported in *Radiation Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting

Table 2. Concentrations of radionuclides in milk for September 1972 and 12-month period October 1971 through September 1972

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:						
Ala:	Montgomery[c]	P	NA	7	0	6
Alaska:	Palmer[c]	P	5	5	0	9
Ariz:	Phoenix[c]	P	NA	0	0	0
Ark:	Little Rock[c]	P	NA	11	0	7
Calif:	Sacramento[c]	P	NA	1	0	0
	San Francisco[c]	P	NA	1	0	0
	Del Norte	P	9	12	0	11
	Fresno	P	0	2	0	5
	Humboldt	P	3	4	0	8
	Los Angeles	P	0	2	0	4
	Mendocino	P	0	5	0	6
	Sacramento	P	0	2	0	5
	San Diego	P	0	1	0	4
	Santa Clara	P	0	1	0	6
	Shasta	P	0	3	0	7
	Sonoma	P	0	2	0	6
Colo:	Denver[c]	P	NA	5	0	4
	East	R	NS	NA	NS	0
	Northeast	R	NA	NA	[d] 0 (21)	0
	Northwest	R	NS	NA	NS	0
	South Central	R	NS	NS	NS	NS
	Southeast	R	NS	NA	NS	0
	Southwest	R	NA	NA	[d] 0	0
	West	R	NS	NA	NS	4
Conn:	Hartford[c]	P	NA	6	0	7
	Central	P	6	7	11	13
Del:	Wilmington[c]	P	NA	8	0	7
D.C:	Washington[c]	P	NA	7	0	6
Fla:	Tampa[c]	P	5	5	33	39
	Central	R	3	5	84	44
	North	R	4	8	15	18
	Northeast	R	5	6	38	34
	Southeast	R	5	6	23	56
	Tampa Bay area	P	5	5	39	37
	West	R	7	9	0	15
Ga:	Atlanta[c]	P	8	9	7 (2)	11
Hawaii:	Honolulu[c]	P	3	3	0	1
Idaho:	Idaho Falls[c]	P	3	4	0	0
Ill:	Chicago[c]	P	4	6	0	9
Ind:	Indianapolis[c]	P	NA	6	0	2
	Central	P	10	7	0	10
	Northeast	P	5	7	0	12
	Northwest	P	8	8	10	12
	Southeast	P	7	8	10	12
	Southwest	R	7	8	10	12
Iowa:	Des Moines[c]	P	NA	4	0	1
	Iowa City	P	7	6	10	9
	Des Moines	P	5	6	0	9
	Little Cedar	P	NS	6	NS	10
	Spencer	P	5	7	11	12
Kans:	Wichita[c]	P	NA	8	0	1
	Coffeyville	P	6	7	0	10
	Dodge City	P	6	5	0	8
	Falls City, Nebr	R	8	3	0	8
	Hays	P	7	9	0	9
	Kansas City	P	7	8	0	11
	Topeka	P	6	7	11	9
	Wichita	P	9	9	0	8
Ky:	Louisville[c]	P	NA	8	0	6
La:	New Orleans[c]	P	12	13	0	6
Maine:	Portland[c]	P	NA	6	21	19
Md:	Baltimore[c]	P	NA	7	13	4
Mass:	Boston[c]	P	6	7	15	10
Mich:	Detroit[c]	P	NA	7	15	8
	Grand Rapids[c]	P	NA	7	0	7
	Bay City	P	6	5	0	10
	Charlevoix	P	5 (3)	7	0 (3)	12
	Detroit	P	3	5	13	9
	Grand Rapids	P	4	5	0	7
	Lansing	P	0	6	11	11
	Marquette	P	3	6	14	20
	Monroe	P	NA	3	NA	4
	South Haven	P	3 (3)	5	0 (3)	7
Minn:	Minneapolis[c]	P	NA	8	12	16
	Bemidji	P	5	7	20	18
	Duluth	P	16	15	37	27
	Fergus Falls	P	8	8	11	15
	Little Falls	P	20	18	44	40
	Mankato	P	NS	5	NS	11
	Marshall	P	6	6	0	11

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for September 1972 and 12-month period October 1971 through September 1972—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—continued						
Minn:	Minneapolis	P	9	18	0	15
	Rochester	P	5	7	0	12
Miss:	Jackson[c]	P	NA	10	0	7
Mo:	Kansas City[c]	P	NA	7	0	3
	St. Louis[c]	P	NA	7	0	3
Mont:	Helena[c]	P	NA	5	0	4
Nebr:	Omaha[c]	P	NA	5	0	1
Nev:	Las Vegas[c]	P	NA	2	0	0
N.H:	Manchester[c]	P	NA	8	19	17
N.J:	Trenton[c]	P	NA	7	15	6
N. Mex:	Albuquerque[c]	P	NA	2	0	0
N.Y:	Buffalo[c]	P	4	6	0	5
	New York City[c]	P	NA	8	0	8
	Syracuse[c]	P	NA	7	0	6
	Albany	P	5 (3)	7	0 (4)	0
	Buffalo	P	NS	NS	0	0
	Massena	P	NS	NS	19	0
	New York City	P	7	7	11	0
	Syracuse	P	NS	NS	0	0
N.C:	Charlotte[c]	P	NA	10	13	8
N. Dak:	Minot[c]	P	NA	9	0	11
Ohio:	Cincinnati[c]	P	NA	7	0	3
	Cleveland[c]	P	NA	6	19	8
Okla:	Oklahoma City[c]	P	NA	6	0	6
Oreg:	Portland[c]	P	4	5	0	3
	Baker	P	NA		12	1
	Coos Bay	P	NA		21	2
	Eugene	P	NA		0	1
	Medford	P	NA		17	4
	Portland composite	P	NA		15	6
	Portland local	P	NA		14	5
	Redmond	P	NA		0	0
	Tillamook	P	NA		0	11
Pa:	Philadelphia[c]	P	NA	7	0	3
	Pittsburgh[c]	P	NA	9	0	5
	Dauphin	P	5	7	0	11
	Erie	P	7	7	11	12
	Philadelphia	P	5	5	0	10
	Pittsburgh	P	8	7	0	14
R.I:	Providence[c]	P	NA	6	15	11
S.C:	Charleston[c]	P	7	9	11	13
S. Dak:	Rapid City[c]	P	NA	7	0	3
Tenn:	Chattanooga[c]	P	NA	8	0	8
	Memphis[c]	P	NA	7	11	3
	Chattanooga	P	10	10	11	13
	Clinton	R	13	10	19	14
	Fayetteville	R	10	10	0 (2)	6
	Kingston	R	8	9	0 (2)	7
	Knoxville	P	8	8	0 (2)	8
	Lawrenceburg	R	6	8	0	10
	Nashville	P	10	8	0 (2)	6
	Pulaski	R	7	7	0 (2)	8
Tex:	Austin[c]	P	NA	3	0	0
	Dallas[c]	P	NA	6	0	0
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City[c]	P	0	3	0	3
Vt:	Burlington[c]	P	NA	6	0	9
Va:	Norfolk[c]	P	NA	8	0	6
Wash:	Seattle[c]	P	NA	5	15	5
	Spokane[c]	P	NA	5	0	7
	Benton County	R	0	1	0	0
	Franklin County	R	NS	1	NS	2
	Longview	R	3	3	0	0
	Sandpoint, Idaho	R	4	10	0	15
	Skagit County	R	7	7	13	5
W. Va:	Charleston[c]	P	NA	8	0	5
Wisc:	Milwaukee[c]	P	NA	5	12	6
Wyo:	Laramie[c]	P	NA	4	0	2

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for September 1972 and 12-month period October 1971 through September 1972—continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA:					
Alberta: Calgary	P	6	7	16	19
Edmonton	P	8	7	13	25
British Columbia:					
Vancouver	P	9	8	16	23
Manitoba: Winnipeg	P	5	6	0	20
New Brunswick:					
Fredericton	P	NA	NA	NA	NA
Newfoundland:					
St. John's	P	28	19	31	26
Nova Scotia:					
Halifax	P	8	9	0	19
Ontario: Ottawa	P	6	6	0	11
Sault Ste. Marie	P	10	11	25	26
Thunder Bay	P	10	10	20	22
Toronto	P	2	3	0	10
Windsor	P	3	3	0	8
Quebec: Montreal	P	6	6	0	14
Quebec	P	9	9	12	25
Saskatchewan:					
Regina	P	6	7	0	16
Saskatoon	P	6	7	0	15
CENTRAL AND SOUTH AMERICA:					
Canal Zone:					
Cristobal[c]	P	NA	1	36	12
Chile: Santiago	P	1	1	0	1
Colombia: Bogota	P	1	1	0	0
Ecuador: Guayaquil	P	0	0	0	0
Jamacia: Montego Bay	P	2	2	110	52
Puerto Rico:					
San Juan[c]	P	NA	3	0	5
Venezuela:					
Caracas	P	0	0	0	0
PMN network average[e]		5	6	4	6

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:
Cesium-137: Colorado—25 pCi/liter
Oregon—15 pCi/liter

[e] This entry gives the average radionuclide concentration for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply; the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for September 1972 and the 12-month period, October 1971 to September 1972. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131,

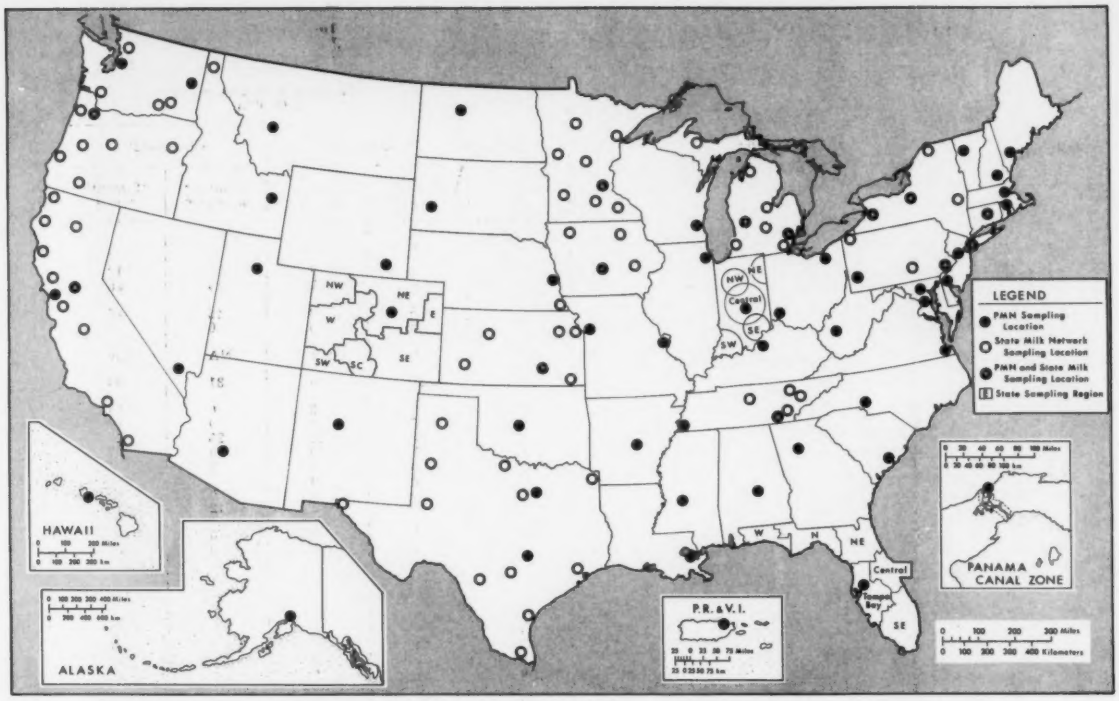

Figure 2. State and PMN milk sampling stations in the United States

and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for September 1972 were below the respective reporting levels. Table 3 gives monthly average for those stations at which strontium-89, iodine-131, and barium-140 were detected.

Strontium-90 monthly averages ranged from 0 to 20 pCi/liter in the United States for September 1972, and the highest 12-month average was 18 pCi/liter (Little Falls and Minneapolis, Minn.) representing 9.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 84 pCi/liter in the United States for September 1972, and the highest 12-month average was 56 pCi/liter (Southeast Florida) representing 1.6 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*7*) and Jamaica.

Table 3. Strontium-89, iodine-131, and barium-140 in milk,[1] September 1972

Sampling location		Concentration (pCi/liter)	
		Strontium-89	Barium-140
United States:			
Colo:	Southwest		28
N.Y:	Albany	6	
Canada:			
Alberta:	Edmonton	7	
British Columbia:	Vancouver	7	
Manitoba:	Winnipeg	6	
Nova Scotia:	Halifax	9	
Quebec:	Quebec	8	
Saskatchewan:	Saskatoon	6	

[1] No iodine-131 detected.

Acknowledgement

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Bureau of Radiological Health
Environmental Health & Consumer Protection Program
California Department of Public Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intake of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January-June 1971	December 1972
Carbon-14 in Total Diet and Milk	July-December 1971	May 1972
Connecticut Standard Diet	January-December 1971	December 1972
Institutional Total Diet	October-December 1971 and 1971 Annual Summary	November 1972
Radiostrontium in Milk	January-December 1971	November 1972
Strontium-90 in Tri-City Diets	January-December 1971	December 1972

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January-December 1970	June 1972
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	January-December 1970	December 1971
Michigan	January-June 1970	November 1971
Minnesota Municipal Water	July-1970-June 1971	November 1972
New York	July-December 1970 and January-June 1971	May 1972
North Carolina	1968-1970	September 1972
Radiostrontium in Tap Water, *HASL*	July-December 1971	November 1972
Washington	July 1969-June 1970	March 1972
Water Surveillance Programs, *NERC–LV*	January-March 1972	December 1972

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Gross Radioactivity in Surface Waters of the United States May 1972

Office of Water Planning and Standards
U.S. Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1967 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Water Planning and Standards. Regional offices of the Environmental Protection Agency are responsible for the collection and retrieval system. Radioactivity analyses are performed in the centralized laboratories of the Office of Water Planning and Standards (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). With the publication of data for January 1971, this activity was resumed as a monthly report series. The unpublished data for the time interval of November 1968 through December 1970 will be the subject of a future summary article.

Table 1 presents the gross alpha and beta radioactivity results for samples collected from 11 rivers during May 1971. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are collected for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards Handbook 86 (*2*) and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements.

Table 2 presents the strontium-90 results on samples collected and composited from 27 rivers during the third quarter of the 1971 water year (April-June 1971). The analytical procedures used for determining strontium-90 are described in *Radionuclide Analysis of Environmental Samples* (*2*). Results are reported for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards Handbook 85 (*3*) and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements.

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(*3*) U.S. DEPARTMENT OF COMMERCE. Physical Aspects of Irradiation, Recommendation of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 85, (March 31, 1964).

Table 1. Gross radioactivity in U.S. surface waters, May 1972

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Clinch River:					
Kingston, Tenn.	3	<0.4	<0.5	2	6
		<.4	.6	2	6
		<.3	<.4	3	5
Colorado River:					
Colorado-Utah State line	1	7.7	1.9	30	11
DeBeque, Colo.	1	<1.0	<1.5	11	11
Grand Junction, Colo.	1	<2.0	2.5	20	15
Lee's Ferry, Ariz.	1	<.3	5.2	3	18
Silt, Colo.	1	1.4	4.2	5	11
Moab, Utah:					
Highway bridge	3	5.1	4.5	11	9
		4.3	2.8	15	8
		8.1	10.8	32	11
Above Mill Creek	4	5.8	3.8	13	8
		3.6	5.8	16	9
		16.2	22.7	35	22
		11.9	4.1	31	13
Dolores River:					
Bedrock, Colo.	4	1.3	2.0	6	16
		1.5	2.5	7	11
		7.7	.7	22	2
		1.0	1.7	6	6
Gateway, Colo.	4	.6	5.8	6	39
		2.8	25.1	8	31
		6.0	3.0	21	8
		4.2	5.1	19	30
Green River:					
Greendale, Utah	1	<.3	3.4	3	15
Mississippi River:					
Burlington, Iowa	1	3.9	2.4	7	7
Dubuque, Iowa	1	2.5	2.1	7	7
Missouri River:					
St. Joseph, Mo.	1	12.5	<1.2	47	15
St. Louis, Mo.	1	18.5	<1.2	45	14
Ohio River:					
Cincinnati, Ohio	3	<.6	<.7	6	5
		4.4	.9	13	5
		.3	.6	3	5
Roanoke River:					
John Kerr Dam, Va.	3	<.3	<.6	3	4
		<.4	<.3	<2	4
		<.4	<.4	<2	3
San Miguel River:					
Uravan, Colo.	3	1.9	5.7	6	11
		<.2	<2.0	3	11
		1.1	2.3	9	11
Below Uravan, Colo.	4	3.4	20.0	5	14
		2.5	2.3	9	14
		<.5	11.7	11	18
		<.4	23.5	2	21
Naturita, Colo.	4	1.0	<.9	<2	<2
		<.4	<1.5	3	8
		<.5	<1.1	6	6
		1.5	<.7	8	5
St. Lawrence River:					
Massena, N.Y.	4	<.4	<.7	<2	3
		<.4	<.7	<2	4
		.6	.7	3	6
		<.3	<.5	2	6
Yampa River:					
Maybell, Colo.	1	1.7	<.6	4	5

Table 2. Radioactivity in surface waters, April–June 1971

River and location	Strontium-90 (pCi/liter)
Allegheny River:	
Pittsburgh, Pa	1.4
Beaver River:	
New Brighton, Pa	1.6
Big Sandy River:	
Wayne County, W. Va	1.0
Big Sioux River:	
Brandon, S. Dak	3.6
Clinch River:	
Kingston, Tenn	2.3
Cheyenne River:	
Edgemont, S. Dak	2.8
Great Miami River:	
American Material Bridge, Hamilton, Ohio	<.5
Liberty-Fairfield, Ohio	.9
Lost Bridge, Ohio	.9
Sellars Road Bridge, Hamilton, Ohio	1.5
Guyandotte River:	
Guyandotte, W. Va	<.5
Kanawha River:	
Mason County, W. Va	.7
Winfield Dam, W. Va	.8
Kentucky River:	
Dam No. 1	.7
Licking River:	
Covington, Ky	1.1
Little Miami River:	
Cincinnati, Ohio	1.3
Maumee River:	
Toledo, Ohio	1.2
Mississippi River:	
Burlington, Iowa	1.9
Missouri River:	
Bismarck, N. Dak	2.8
St. Joseph, Mo	1.9
St. Louis, Mo	2.0
Monongahela River:	
Pittsburgh, Pa	1.9
Muskingum River:	
Dam No. 2, Mich	2.3
Ohio River:	
Addison, Ohio	1.6
Ashland, Ky	2.8
Eldean Mills, Ohio	1.6
Hancock, W. Va	1.3
Ironton, Ohio	1.7
Kyger Creek, W. Va	.8
Madison, Ind	1.8
Markland Dam, Ind	.8
Maysville, Ky	1.8
New Martinsville, Ohio	2.6
Portsmouth, Ohio	1.4
South Heights, Pa	1.3
Above Muskingum River, Ohio	1.6
Warwood, W. Va	1.7
Platte River:	
Plattsmouth, Nebr	1.5
Rainy River:	
International Falls, Minn	2.9
Roanoke River:	
John Kerr Dam, Va	.8
Sabine River:	
Rulyt, Tex	1.9
St. Lawrence River:	
Massena, N.Y	1.9
Susquehanna River:	
Conowingo Dam, Md	1.6
Holtwood, Pa	2.7
Whitewater River: (Ohio)	
Suspension Bridge	1.8
Yazoo River:	
Vicksburg, Miss	1.0
Yellowstone River:	
Sidney, Mont	2.2

Trituim Surveillance System, April-June 1972

Office of Radiation Programs
Environmental Protection Agency

The Tritium Surveillance System is an expansion of previous tritium surveillance activities conducted by the Office of Radiation Programs, Environmental Protection Agency (EPA). The principal effort in the past by the Office of Radiation Programs related to tritium releases has been the Tritium in Surface Water Network. This network was established in 1964, to measure and monitor tritium concentrations in major river systems in the United States and to provide surveillance at surface water stations downstream from selected nuclear facilities. The network consisted of selected stations from existing water pollution sampling stations operated by the Office of Water Programs of EPA. The final data from this network for the period January-June 1970, have been published previously (*1*).

Another effort of the Office of Radiation Programs was a tritium in precipitation program. This project was established in 1967 at selected Radiation Alert Network (RAN) stations covering the United States, including Alaska and Hawaii. The RAN is operated by the Office of Air Programs of EPA. The data from this project for the period July-December 1969, have been published previously (*2*). Due to the increased interest in tritium releases from nuclear facilities and the potential long-term accumulation in the environment, a national system was established to incorporate these projects or networks into one overall system.

Present network

The Tritium Surveillance System consists of 70 drinking water samples collected quarterly at the RAN stations, precipitation samples collected daily and analyzed monthly from 8 of the RAN stations (figure 1), and samples collected quarterly at 39 surface water stations (figure 2). The specific locations for the surface water sampling system were determined by examining the water drainage areas to assure that a representative sample from a large area or region was obtained, and if possible, incorporating several nuclear facility sites. All nuclear facilities that were operating, being constructed, or planned through 1975 were considered. Consideration was also given to the current surveillance programs of the States that will be involved in the collection of the samples. The surface water samples are collected quarterly either downstream from a nuclear facility or at a background station.

The tap water samples are collected by the RAN operators on a quarterly basis. The precipitation samples are also collected by the RAN operators on a daily basis.

All samples are sent to either the Eastern Environmental Radiation Laboratory or the National Environmental Research Center—Las Vegas for analysis. Analytical values which are not statistically significant at the 2-sigma confidence level have been reported as zero.

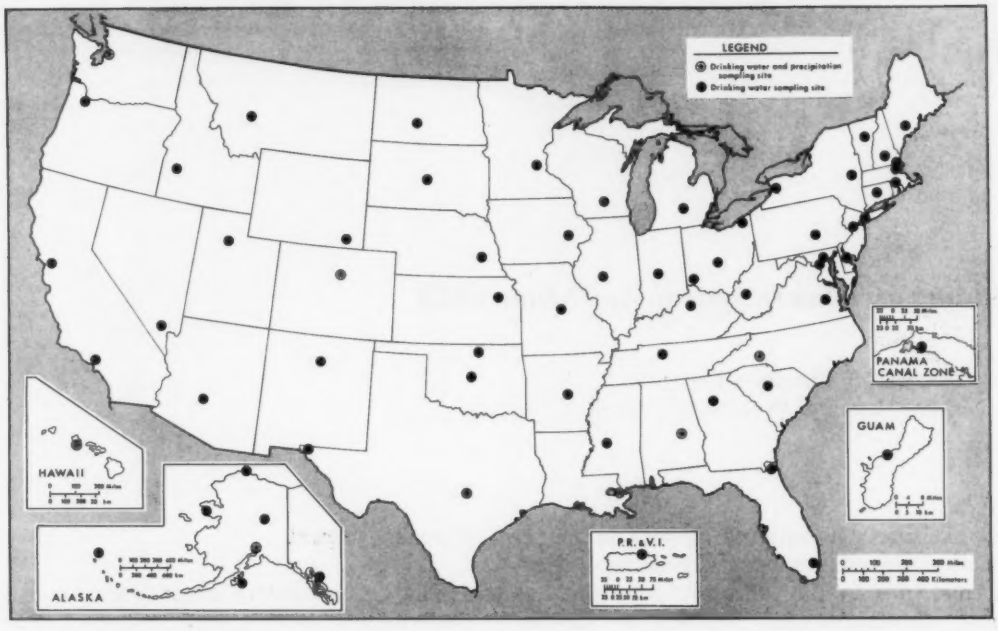

Figure 1. Drinking water and precipitation sampling locations for tritium surveillance system

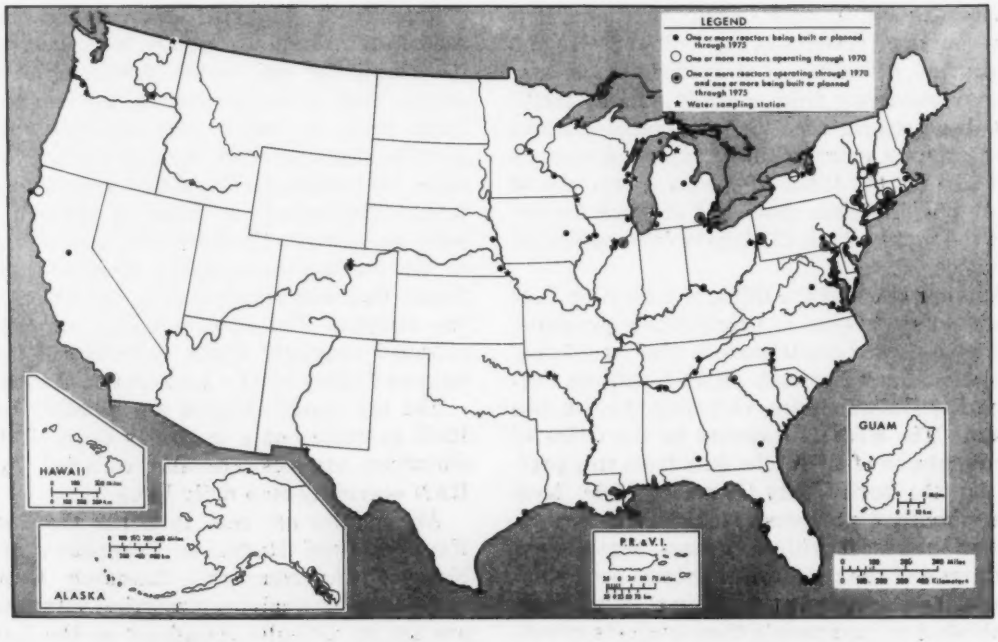
LEGEND
One or more reactors being built or planned through 1975
One or more reactors operating through 1970
One or more reactors operating through 1970 and one or more being built or planned through 1975
Water sampling station
HAWAII
ALASKA
GUAM
P.R. & V.I.

Figure 2. Surface water sampling locations for tritium surveillance system

Results and discussion

Table 1 presents the tritium concentrations in drinking water at the RAN stations for April-June 1972. The average tritium concentration was 0.4 nCi/liter.

Previous articles on the Tritium Surveillance System have reported dose equivalents from tritium in body water based on a relationship derived by Moghissi and Porter (*3*). Their relationship assumed a quality factor of 1.7 for tritium beta rays based on a 1966 ICRP recommendation (*4*). Recently the NCRP has recommended a quality factor of 1 for tritium beta rays (*5*) and this recommendation has been adopted for this and subsequent reports. Following the notation adopted by the ICRU (*6*) substitution of a quality factor of 1 in Moghissi and Porter calculations yields:

$$H \text{ (mrem/year)} = 0.1C \text{ (nCi/liter)}$$

Where H is the dose equivalent rate and C represents the tritium concentration in body water.

Assuming that the concentration of tritium in all water taken into the body is equal to that found in the drinking water and also that the specific activity of tritium in the body is essentially the same as that in the drinking water, then the radiation dose may be estimated.

The highest individual concentration of tritium observed in the drinking water was 1.8 nCi/liter during the second quarter. This corresponds to a dose of 0.18 mrem/a, or less than 0.11 percent of the Federal Radiation Council's Radiation Protection Guide (170 mrem/a) for an average dose to a suitable sample of the exposed population.

The tritium concentrations for the surface water samples are given in table 2. The highest tritium concentration was 5.2 nCi/liter for the second quarter. Assuming that the specific activity of tritium in the body is essentially the same as that in surface water, this concentration corresponds to a dose of 0.52 mrem/a, or 0.31 percent of the Radiation Protection Guide.

The monthly analyses for tritium in precipitation samples at the 8 RAN stations are shown in table 3.

Table 1. Tritium concentration in tap water (RAN stations) April–June 1972

Location		Date collected (1972)	Tritium concentration[a] (nCi/liter ± 2σ)[b]
Ala:	Montgomery	4/4	0.2
Alaska:	Anchorage	4/4	1.0
	Attu Island	NS	
	Fairbanks	NS	
	Juneau	4/3	.5
	Kodiak	NS	
	Nome	4/21	.8
	Point Barrow	4/1	1.3
Ariz:	Phoenix	4/3	.4
Ark:	Little Rock	4/5	0
Calif:	Berkeley	4/3	.5
	Los Angeles	4/6	.4
C.Z:	Ancon	4/25	0
Colo:	Denver	4/4	.8
Conn:	Hartford	4/12	.3
Del:	Dover	4/10	0
D.C:	Washington	4/28	0
Fla:	Jacksonville	4/5	0
	Miami	4/5	0
Ga:	Atlanta	4/4	.2
Guam:	Agana	4/4	0
Hawaii:	Honolulu	4/3	0
Idaho:	Boise	NS	
Ill:	Springfield	4/7	.4
Ind:	Indianapolis	4/5	.4
Iowa:	Iowa City	4/4	.5
Kans:	Topeka	4/14	.4
Ky:	Frankfort	4/10	.3
La:	New Orleans	4/3	.5
Maine:	Augusta	4/7	.4
Md:	Baltimore	4/6	.3
Mass:	Lawrence	4/11	.2
	Winchester	4/7	.4
Mich:	Lansing	4/6	0
Minn:	Minneapolis	4/11	.5
Miss:	Jackson	4/3	0
Mo:	Jefferson City	4/3	0
Mont:	Helena	4/3	.9
Nebr:	Lincoln	4/3	.5
Nev:	Las Vegas	4/10	1.0
N.H:	Concord	4/10	.2
N.J:	Trenton	4/7	.3
N. Mex:	Sante Fe	4/19	1.7 ±0.3
N.Y:	Albany	4/10	.3
	Buffalo	NS	
	New York City	4/15	.4
N.C:	Gastonia	4/6	.2
N. Dak:	Bismarck	4/11	1.3
Ohio:	Cincinnati	4/6	.4
	Columbus	4/10	.4
	Painesville	4/10	.4
Okla:	Oklahoma City	4/3	.3
	Ponca City	4/5	.4
Oreg:	Portland	4/3	0
Pa:	Harrisburg	4/12	.5
P.R:	San Juan	4/24	0
R.I:	Providence	4/18	.2
S.C:	Columbia	4/3	.4
S. Dak:	Pierre	4/3	1.8 ± .3
Tenn:	Nashville	4/4	.4
Tex:	Austin	4/10	0
	El Paso	4/4	.3
Utah:	Salt Lake City	4/7	.3
Vt:	Barre	4/10	.3
Va:	Richmond	4/6	.2
Wash:	Seattle	4/5	.2
	Spokane	4/3	.5
W. Va:	Charleston	4/7	.3
Wisc:	Madison	4/7	0
Wyo:	Cheyenne	4/27	1.0
Average			0.4

[a] The minimum detection limit for all samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero.
[b] The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.
NS, no sample.

Table 2. Tritium concentration in surface water, April–June 1972

Location		Water source	Facility	Collection date (1972)	Concentration[a] (nCi/liter ±2σ)[b]
Ala:	Decatur	Tennessee River	Browns Ferry	[c]3/28	0.4
Ark:	Morrilton	Arkansas River	Arkansas Nuclear	4/12	.6
Calif:	Eureka	Humboldt Bay	Humboldt Bay	4/24	0
	San Onofre	Pacific Ocean	San Onofre	4/10	0
Colo:	Greely	South Platte River	Fort St. Vrain	4/4	1.2
Conn:	East Haddam	Connecticut River	Connecticut Yankee and Vermont Yankee	4/12	.4
	Waterford	Long Island Sound	Millstone	4/19	0
Fla:	Crystal River	Gulf of Mexico	Crystal River	4/14	0
	Homestead	Biscayne Bay	Turkey Point	5/18	0
Idaho:	Buhl	Snake River	National Reactor Testing Station	4/3	.7
Ill:	Moline	Mississippi River	Quad-Cities	4/20	.4
	Morris	Illinois River	Dresden and Argonne	4/22	.3
La:	New Orleans	Mississippi River	(Several)	4/3	.4
Md:	Conowingo	Susquehanna River	Peach Bottom and Three Mile Island	4/27	.3
	Lusby	Chesapeake Bay	Calvert Cliffs	4/20	.2
Mass:	Rowe	Deerfield River	Yankee	4/20	.3
Mich:	Charlevoix	Lake Michigan	Big Rock Point	4/16	.4
	Monroe	Lake Erie	Enrico Fermi	4/10	.5
	South Haven	Lake Michigan	Palisades	4/6	.3
Minn:	Monticello	Mississippi River	Monticello	4/11	.7
Nebr:	Rulo	Missouri River	Fort Calhoun and Cooper	4/5	1.1
Nev:	Boulder City	Colorado River	Background	4/13	1.4
N.J:	Bayside	Delaware River	Salem	4/25	.2
N.Y:	Ossining	Hudson River	Indian Point	4/17	.3
	Oswego	Lake Ontario	Nine Mile Point and R. E. Ginna	4/11	.4
	Poughkeepsie	Hudson River	Background	4/12	.3
N.C:	Charlotte	Catawba River	Wm. B. McGuire	NS	
Oreg:	Westport	Columbia River	Rainier and Hanford	5/25	0.7
S.C:	Allendale	Savannah River	Savannah River Plant and Oconee	4/5	.4
	Hartsville	Lake Robinson	H. B. Robinson	4/18	1.6
Tenn:	Kingston	Clinch River	Oak Ridge	4/3	5.2
Tex:	El Paso	Rio Grande	Los Alamos	4/4	.4
Vt:	Vernon	Connecticut River	Vermont Yankee	4/7	.3
Va:	Newport News	James River	Surry	4/4	.3
Wash:	Northport	Columbia River	Background	4/26	.9
	Pasco	Columbia River	Hanford	4/5	.9
W. Va:	Wheeling	Ohio River	Shippingport	4/4	.4
Wisc:	Two Creeks	Lake Michigan	Point Beach and Kewaunee	4/17	.3
	Victory	Mississippi River	LaCrosse and Prairie Island	4/14	.4
Average					0.6

[a] The minimum detection limit for all samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero.
[b] The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.
[c] Sample collected early.
NS, no sample.

Table 3. Tritium concentration in precipitation from RAN stations, April–June 1972

Location		Tritium concentration[a] (nCi/liter ±2σ)		
		April	May	June
Ala:	Montgomery	0.6	0.4	0.5
Alaska:	Anchorage	.3	.4	.4
Colo:	Denver	.4	.6	.6
Hawaii:	Honolulu	0	NS	0
La:	New Orleans	0	0	0
N.C:	Gastonia	0	.3	.5
Tex:	Austin	0	0	0
Wash:	Seattle	0	.3	.3

[a] The minimum detection limit for these samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero. The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.
NS, no sample.

Other coverage in *Radiation Data and Reports:*

Period	Issue
April-June 1971	November 1971
July-September 1971	April 1972
October-December 1971	May 1972
January-March 1972	August 1972

REFERENCES

(*1*) BUREAU OF RADIOLOGICAL HEALTH. Tritium in surface water network, January-June 1970. Radiol Health Data Rep 11:638–639 (November 1970).

(*2*) BUREAU OF RADIOLOGICAL HEALTH. Tritium in precipitation (RAN), July-December 1969. Radiol Health Data Rep 11:354–355 (July 1970).

(*3*) MOGHISSI, A. A. and C. R. PORTER. Tritium in surface waters in the United States, 1966. Radiol Health Data Rep 9:337–339 (July 1968).

(*4*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Recommendations of the International Commission on Radiological Protection (Adopted September 17, 1965), ICRP Publication 9 (1969).

(*5*) NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS. Basic Radiation Protection Criteria, NCRP Report No. 39, National Council on Radiation Protection and Measurements, Washington, D.C. 20008 (January 15, 1971).

(*6*) INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Radiation Quantities and Units, ICRU Report No. 19, Washington, D.C. 20014 (July 1972).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican National Institute of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January-December 1970	December 1971
Surface Air Sampling Program 80th Meridian Network, *HASL*	January-December 1969	February 1972

1. Radiation Alert Network September 1972

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 69 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during September 1972.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, September 1972

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Number of samples	Total depth (mm)	Precipitation		
			Maximum	Minimum	Average[a]			Field estimation of deposition		
								Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	16	2	0	1	3	51	3	51	7
Alaska:	Anchorage	2	0	0	0	0				
	Attu Island	30	0	0	0	0				
	Fairbanks	0				0				
	Juneau	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	19	10	1	4	0				
Ark:	Little Rock	20	3	0	1	0				
Calif:	Berkeley	20	1	0	0	2	31	2	31	0
	Los Angeles	20	2	0	1	0				
C.Z:	Ancon	15	0	0	0	0				
Colo:	Denver	20	8	1	3	4	20	[b]		
Conn:	Hartford	20	2	0	1	6	38	6	38	0
Del:	Dover	20	2	0	0	0				
D.C:	Washington	26	3	0	0	0				
Fla:	Jacksonville	20	2	0	0	4	179	3	170	10
	Miami	0				0				
Ga:	Atlanta	16	2	1	1	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	18	1	0	0	1	22	[b]		
Idaho:	Boise	19	2	0	1	4	15	4	15	5
Ill:	Springfield	0				0				
Ind:	Indianapolis	19	2	0	1	0				
Iowa:	Iowa City	19	2	0	1	6	59	6	59	3
Kans:	Topeka	19	3	1	1	3	49	3	49	1
Ky:	Frankfort	13	4	1	2	0				
La:	New Orleans	18	1	0	0	8	63	[b]		
Maine:	Augusta	16	2	0	1	4	90	4	90	0
Md:	Baltimore	19	3	0	1	3	23	3	23	0
Mass:	Lawrence	20	2	0	1	5	80	5	80	0
	Winchester	18	3	0	1	6	75	6	75	0
Mich:	Lansing	20	2	0	0	6	71	6	71	7
Minn:	Minneapolis	20	2	0	1	6	70	6	70	8
Miss:	Jackson	15	2	0	1	4	48	4	48	0
Mo:	Jefferson City	20	2	0	1	7	130	7	130	0
Mont:	Helena	14	2	0	1	0				
Nebr:	Lincoln	2	6	1	2	0				
Nev:	Las Vegas	17	4	0	2	0				
N.H:	Concord	0				0				
N.J:	Trenton	20	3	0	1	9	36	9	36	1
N. Mex:	Santa Fe	14	3	0	1	0				
N.Y:	Albany	0				0				
	Buffalo	19	1	0	0	0				
	New York City	0				0				
N.C:	Gastonia	19	10	1	4	5	68	[b]		
N. Dak:	Bismarck	19	4	1	2	3	12	3	12	0
Ohio:	Cincinnati	0				0				
	Columbus	2	1	0	1	0				
	Painesville	20	1	0	0	9	149	9	149	28
Okla:	Oklahoma City	10	6	1	2	1	28			
	Ponca City	11	3	1	1	3	43	3	43	0
Oreg:	Portland	20	1	0	0	5	56	5	56	3
Pa:	Harrisburg	16	4	0	1	0				
P.R:	San Juan	0				0				
R.I:	Providence	20	2	0	0	0				
S.C:	Columbia	19	4	0	1	4	128	4	128	0
S. Dak:	Pierre	19	8	1	3	0				
Tenn:	Nashville	19	3	0	1	6	109	6	109	0
Tex:	Austin	20	5	1	3	3	45	[b]		
	El Paso	18	4	0	1	0				
Utah:	Salt Lake City	30	2	0	1	5	21	5	21	5
Vt:	Barre	19	5	0	2	5	32	5	32	2
Va:	Richmond	17	1	0	0	0				
Wash:	Seattle	8	0	0	0	4	74	[b]		
	Spokane	14	2	0	1	0				
W. Va:	Charleston	20	3	0	1	6	41	6	41	6
Wisc:	Madison	19	1	0	0	9	110	9	110	7
Wyo:	Cheyenne	18	5	1	2	0				
	Network summary	1,000	10	0	1	159	79	5	67	4

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

2. Canadian Air and Precipitation Monitoring Program,[1] September 1972

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for September 1972 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, September 1972

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	4	0.0	0.0	0.0	28	1.6
Coral Harbour	4	.0	.0	.0	11	.3
Edmonton	4	.0	.0	.0	43	1.3
Ft. Churchill	4	.0	.0	.0	21	1.2
Fredericton	4	.0	.0	.0	10	1.0
Goose Bay	4	.0	.0	.0	15	1.2
Halifax	7	.1	.0	.1	17	1.1
Inuvik	4	.0	.0	.0	22	.9
Montreal	4	.0	.0	.0	15	1.0
Moosonee	4	.1	.0	.0	29	1.7
Ottawa	4	.1	.0	.0	18	1.3
Quebec	4	.0	.0	.0	17	1.3
Regina	4	.0	.0	.0	20	.3
Resolute	4	.0	.0	.0	14	1.1
St. John's, Nfld	4	.0	.0	.0	13	1.3
Saskatoon	4	.0	.0	.0	53	.6
Sault Ste. Marie	4	.1	.0	.0	20	1.7
Thunder Bay	4	.1	.0	.0	15	1.0
Toronto	4	.0	.0	.0	10	1.0
Vancouver	4	.0	.0	.0	19	1.5
Whitehorse	4	.0	.0	.0	18	.7
Windsor	1	.0	.0	.0	13	1.4
Winnipeg	4	.1	.0	.0	35	2.1
Yellowknife	4	.0	.0	.0	30	1.1
Network summary	96	0.1	0.0	0.0	18	1.2

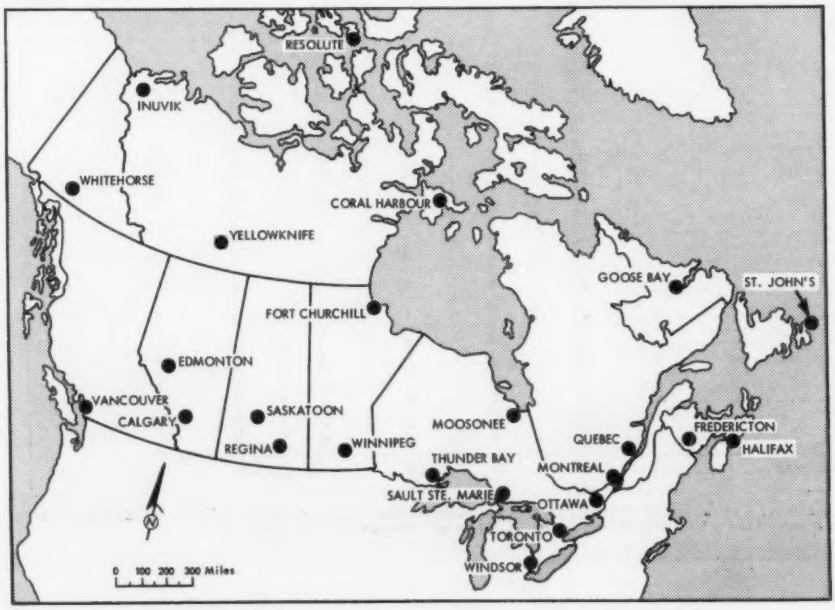

Figure 2. Canadian air and precipitation monitoring program

3. Pan American Air Sampling Program September 1972

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The September 1972 air monitoring results from the participating countries are given in table 3.

Table 3. Summary of gross beta radioactivity in Pan American surface air, September 1972

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	13	0.04	0.01	0.02
Chile:	Santiago	30	.12	.01	.05
Colombia:	Bogota	20	.01	.00	.01
Ecuador:	Cuenca	2	.00	.00	.00
	Guayaquil	19	.07	.00	.03
	Quito	19	.02	.00	.00
Guyana:	Georgetown	10	.01	.00	.01
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	7	.01	.00	.00
West Indies:	Trinidad	0			
Pan American summary		120	0.12	0.00	0.02

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

Figure 3. Pan American Air Sampling Program stations

4. California Air Sampling Program September 1972

Bureau of Radiological Health California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continuous sampling of air filtered through a 47

Figure 4. California air sampling program stations

millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity, 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 4 presents the monthly gross beta radioactivity in air for September 1972. The monthly sample results are presented quarterly.

Table 4. Gross beta radioactivity in California air September 1972

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	29	1.29	0.04	0.22
Barstow	30	.70	.06	.20
Berkeley	25	.20	.02	.09
Colfax	30	.29	.01	.12
El Centro	29	1.02	.05	.22
Eureka	29	.17	.00	.07
Fresno	29	.94	.06	.23
Los Angeles	29	.24	.00	.09
Redding	29	.21	.04	.12
Sacramento	29	.62	.04	.15
Salinas	29	1.88	.07	.32
San Bernardino	29	.79	.04	.18
San Diego	28	.49	.01	.11
Santa Rosa	30	.39	.01	.12
Summary	404	1.88	0.00	0.16

5. Mexican Air Moritoring Program May-August 1972

Instituto Nacional de Energía Nuclear
México, D.F.

Until December 1971, the Radiation Surveillance Network of Mexico was operated by the Comision Nacional de Energía Nuclear (CNEN).

In December 1971, the CNEN became the Instituto Nacional de Energía Nuclear (INEN), as a result of a new law passed by Congress.

In the Instituto Nacional de Energía Nuclear, the Comite de Seguridad Radiologíca (Radiological Security Committee) (CSR) is responsible for radiological protection. The Environmental Radioactivity Section (Sección de Radioactividad Ambiental) of the CSR is in charge of monitoring and measuring environmental radioactive contamination in general,

Table 5. Mexican gross beta radioactivity of airborne particulates, May–August 1972

Station	Gross beta radioactivity (pCi/m³)			
	May	June	July	August
Chihuahua:				
Maximum	1.3	<0.2	<0.2	0.11
Minimum	.2	<.2	<.2	<.10
Average[a]	.3	<.2	<.2	<.10
Ensenada:				
Maximum	.6	<.2	<.2	.13
Minimum	<.2	<.2	<.2	.11
Average	<.2	<.2	<.2	(a)
Mérida:				
Maximum	.9	<.2	<.2	.15
Minimum	<.2	<.2	<.2	<.10
Average	<.2	<.2	<.2	<.10
México, D.F:				
Maximum	<.2	<.2	<.2	<.10
Minimum	<.2	<.2	<.2	<.10
Average	<.2	<.2	<.2	(a)
Torreón:				
Maximum	1.1	<.2	<.2	.12
Minimum	<.2	<.2	<.2	<.10
Average	<.2	<.2	<.2	<.10
Veracruz:				
Maximum	.6	<.2	<.2	.21
Minimum	<.2	<.2	<.2	<.10
Average	<.2	<.2	<.2	<.10

[a] Average not calculated for less than five samples.

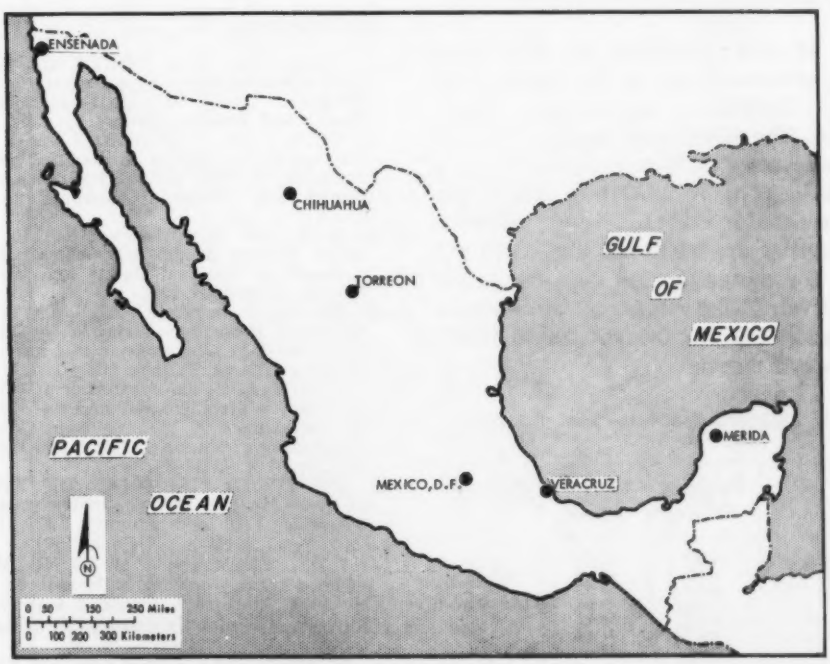

Figure 5. Mexican air sampling locations

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of the environmental radioactivity data follow for Knolls Atomic Power Laboratory and Mound Laboratory.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Knolls Atomic Power Laboratory[2] January-December 1970

General Electric Company
Schenectady, N.Y.

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission (AEC), is to support the Naval Reactors Program of the AEC in the development of atomic power reactors for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors. The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the Kesselring site, located as shown in figure 1.

Figure 1. Environmental monitoring locations, KAPL

Knolls site

The Knolls site is located 5 miles east of Schenectady, N.Y., on the south bank of the Mohawk River. It consists of approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; critical assembly buildings; machine shops, decontamination facilities; radioactive waste storage and processing facilities; and nuclear fuel storage and assembly buildings.

The Knolls site releases small amounts of radioactive materials both to the atmosphere and to the Mohawk River. Prior to the release, exhaust air and liquid waste are treated and carefully monitored. In addition to the in-plant control monitoring, an environmental monitoring program is conducted both on- and offsite at the Knolls site for the following purposes: 1) to

[2] Summarized from "Knolls Atomic Power Laboratory, Knolls Site and Kesselring Site, Annual Environmental Monitoring Report, January-December 1970."

audit the operational control of radioactive waste released to the environment, and 2) to ascertain compliance with the radioactivity standards established by the AEC.

Air monitoring

Potentially radioactive exhaust air from Knolls Site operations is filtered and monitored prior to discharge to the environment. Continuous samples of the effluent are collected and these samples are analyzed on a weekly basis for gross alpha and beta-gamma activity and for selected radionuclides. Monitoring results for 1970 indicate a total discharge of 2.185 mCi consisting of 0.236 mCi of alpha particulate activity, 0.62 mCi of beta-gamma particulate activity and 1.329 mCi of iodine-131. During 1970, the radioactivity concentration in the effluent from each stack averaged less than 5 percent of the appropriate environmental concentration guide for air as given in AEC Manual Chapter 0524.

Liquid waste monitoring

All sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste processing building. The collected waste water is processed and sampled and the samples analyzed to verify that the radioactivity concentration and the total activity content of the processed waste are within established discharge limits. Subsequently, the processed waste water is discharged to the Mohawk River at a controlled rate. During discharge, samples are again collected and composite samples are analyzed.

A continuous proportional sample of the Knolls site combined sewer effluent is collected at the point of release to the Mohawk River. The radioactivity concentration in the effluent is continuously monitored and recorded by passing a portion of the sample through an in-line, lead shielded gamma scintillation detection system. An aliquot of the collected sample is analyzed whenever an increase in the gamma count rate above the normal range of background fluctuations is observed on the recorder.

A total of 28 millicuries of beta-gamma and 0.69 millicuries of alpha activity was discharged to the Mohawk River during 1970. The annual average concentration of beta-gamma activity in the liquid waste was 59 pCi/liter or 6.6 percent of its effective environmental concentration guide for water. The annual average concentration for the uranium isotopes, which comprised 94.6 percent of the total alpha activity, was 1.4 pCi/liter, which is less than 0.01 percent of their effective environmental concentration guide.

Water monitoring

Mohawk River water is sampled continuously at the General Electric Company powerhouse, 8 miles upstream from the Knolls site, and at the Vischer Ferry powerhouse, 1.7 miles downstream. The weekly water samples are composited and analyzed for radioactivity on a monthly basis.

The average beta-gamma concentrations in Mohawk River water samples for each month of 1970 are shown in table 1. These concentrations were all significantly less than the most restrictive environmental concentration guide for strontium-90 given in AEC Manual Chapter 0524.

Sediment Monitoring

The Mohawk River sediment monitoring program at the Knolls site consists of the collection and analyses of Mohawk River sediment in each of three calendar quarters; ice coverage

Table 1. Radioactivity in Mohawk River water near the Knolls site, 1970 [a]

Month	Beta and gamma radioactivity[b] (pCi/liter)	
	G.E. Powerhouse (upstream)	Vischer Ferry (downstream)
January	NS	8.0±4.4
February	<4.8	<4.8
March	<4.8	<4.8
April	5.6±4.7	6.9±4.7
May	5.4±4.7	<4.8
June	5.4±5.0	<4.8
July	<4.8	<4.8
August	5.1±4.7	6.1±4.7
September	<4.8	6.9±4.7
October	<4.8	<4.8
November	<4.8	<4.8
December	<4.8	7.1±4.9

[a] A t-test of these results indicates that, at the 95-percent confidence level, there is no statistical difference between the upriver and downriver concentrations for 1970.
[b] Cesium-137-equivalent.
NS, no sample.

prevents collection during the first calendar quarter. Samples are collected at 15 specific locations and all are analyzed for gamma, gross beta and alpha radioactivity. In addition, selected samples are analyzed for strontium-90.

The average radioactivity concentrations in the quarterly samples of Mohawk River sediment for 1970 are given in table 2. A comparison of these monitoring results with data for previous years indicates that the small quantity of radioactivity discharged in liquid waste during 1970 did not result in an increase in the average radioactivity concentration in river sediment. The variations in quarterly sediment concentrations are within the normally observed ranges for previous years and are attributable to the effects of radioactivity in the sediment from discharges prior to 1964. General concentrations rapidly diminished with increased distances from the sewer outfall.

Liquid effluent monitoring

The principal Knolls Site outfall to the Mohawk River is the one via which processed sanitary and radioactive liquid wastes are discharged. In addition to this outfall, there are eight smaller outfalls via which river water used for cooling, natural stream water and river water pump house drain lines discharge. Although these outfalls are not connected to potential sources of radioactivity, commencing with the third quarter of 1970, they are sampled and the samples analyzed on a quarterly basis. All analytical results for the third and fourth quarters of 1970, were less than the minimum detectable concentrations for gross alpha and beta-gamma activities, strontium-90, and cesium-137.

Perimeter surveys

Surveys are made routinely of the radiation levels at the perimeter of Knolls Site facilities. The surveys for 1970 showed normal background radiation levels for the geographic location. The results of the surveys extrapolated to an annual exposure indicate average radiation levels of less than 0.1 rem per year.

Kesselring site

The Kesselring site, located on approximately 4,000 acres near West Milton, N.Y., is a part of the Knolls Atomic Power Laboratory. Its principal facilities; include the S3G and D1G prototype reactors, equipment service building, fuel service building, and waste treatment facilities. Regular environmental monitoring activities are conducted to assure that laboratory releases of radioactivity to the environment are in compliance with AEC standards.

Air monitoring

Air released from power plant buildings (S3G Hull and D1G Sphere) and the Fuel Service Facility are continuously monitored for air particulate activity. In-stack radioactivity concentrations averaged less than the appropriate concentration guide given in the AEC Manual, Chapter 0524 for the entire 1970 calendar year. The total airborne particulate radioactivity discharged to the environment during the calendar year 1970 was less than 2.65 mCi.

In addition to the environmental airborne radioactivity monitoring, surveys are made semiannually of the radiation levels at the

Table 2. Radioactivity concentrations in Mohawk River sediment, KAPL, 1970 [a]

1970	Number of samples	Total radioactivity (pCi/g wet weight)				Strontium-90 (pCi/g wet weight)		Cesium-137 (pCi/g wet weight)	
		Alpha		Beta					
		Average	Range	Average	Range	Average	Range	Average	Range
January-March	[b]NS								
April-June	15	0.22	<0.07–0.52	20	15 –25	0.39	0.37–0.43	0.89	0.41– 1.7
July-September	15	.26	.11– .40	17	12 –22	.32	<.21– .52	1.0	<.40– 6.8
October-December	9	.24	.11– .80	14	6.2–31	.31	<.21– .71	2.0	<.40–13

[a] Minimum detectable concentration for a 600 g sample of 90-percent confidence level: alpha—0.07 pCi/g; beta-gamma—2.9 pCi/g; strontium-90—0.21 pCi/g; cesium-137—0.40 pCi/g; Concentration for 600 g sample detectable at 90-percent confidence level with ±30 percent precision: alpha—0.38 pCi/g; beta-gamma—11 pCi/g; strontium-90—0.77 pCi/g; cesium-137—1.4 pCi/g. The variation in the detectable levels is the result of differences in the size of sediment aliquots analyzed; i.e., alpha analysis, 10 g; beta analysis, 1 g; strontium-90, 10 g; cesium-137, total sample. Each sediment sample represents a surface area of 230 cm² to a depth of 1 inch.
[b] Samples not collected due to ice on the Mohawk River.

Kesselring site perimeter. Perimeter surveys performed during the year showed normal background radiation levels for the geographic location. The result of the perimeter survey extrapolated to an annual exposure indicates average perimeter radiation levels of <0.1 R/a.

Radioactive liquid waste disposal

The liquid waste from the Kesselring site is collected, processed, and sampled prior to release to the Glowegee Creek. The radioactive waste discharged to the Glowegee Creek in terms of total radioactivity in liquid wastes was 3.16 millicuries for 1970. Radiochemical analyses of these wastes indicated that strontium-89 and strontium-90 concentrations were less than 1 percent of the respective AEC standards for this reporting period. The average result for unidentified radionuclides in the D1G and S3G effluents (8.3 and 79 pCi/liter) represent less than 1 percent and less than 3 percent, respectively of the applicable AEC standard (3 nCi/liter).

Water monitoring

Samples of the Glowegee Creek water are analyzed for radioactivity once each quarter year at two locations, one is about 150 feet above the point where the S3G effluent enters the creek and the other is about 1,500 feet below the D1G effluent discharge point. All Glowegee Creek water analysis results for beta and gamma radioactivity were below 50 pCi/liter, which is the measured concentration that may be considered valid at the 90 percent confidence level with a maximum error of 30 percent. These results indicate that the Kesselring Site effluent did not significantly influence the levels of radioactivity detected in the Glowegee Creek.

Sediment monitoring

Glowegee Creek sediment radioactivity measurements are analyzed on a monthly basis. Sample locations are the same as those listed for Glowegee Creek water sampling. The sediment analysis results are shown in table 3.

General conclusions

As a result of the environmental monitoring program conducted by the Knolls Atomic Power Laboratory, it is concluded that the operation of the Knolls and Kesselring installations did not adversely affect the radioactivity levels of the local environment. The results of the environmental surveys indicate that the levels of radioactivity detected at all times were within the standards established by the U.S. Atomic Energy Commission in the AEC Manual Chapter 0524, "Radiation Protection Standards."

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January-December 1969	October 1972

Table 3. Radioactivity in Glowegee Creek sediment, Kesselring Site, KAPL January–December 1970

1970	Location	Number of samples	Gross gamma radioactivity[a] (pCi/g dry weight)		Cobalt-60[a] (pCi/g dry weight)
			Average	Range	Average
January-March	Upstream	NS			
	Downstream	2	10.4	9.6–11.2	1.3
April-June	Upstream	3	12.9	10.2–16.1	1.5
	Downstream	3	14.8	13.5–15.7	2.3
July-September	Upstream	3	6.1	7.5– 9.9	.99
	Downstream	3	13.9	10.5–17.7	1.9
October-December	Upstream	3	8.1	7.8– 8.5	1.2
	Downstream	3	11.9	9.5–15.5	1.6

[a] The minimum detectable activity (MDA) for cobalt-60 is 0.66 pCi/g of sediment while the MDA for the gross gamma radioactivity analysis is 0.18 pCi/g of sediment. These MDA's are based on average height and density values of sediment samples obtained using a 90-percent confidence level for the error.
NS, no sample, creek bottom frozen.

2. Mound Laboratory[3] January-June 1970

Monsanto Research Corporation
Miamisburg, Ohio

Mound Laboratory is situated on 180 acres of land in Miamisburg, Ohio. This location is 12 miles southwest of Dayton. The laboratory began operation in 1949. Its mission currently includes research, development, engineering, and production of components for the AEC weapons program; separation, purification, and sale of stable isotopes of the noble gases; and development, design, and fabrication of radioisotopic heat sources for medical application and space exploration.

The environmental monitoring program for Mound Laboratory is planned and coordinated with all of the projects conducted at the laboratory. Air and water monitoring in the uncontrolled environs surrounding the laboratory is specified for the radionuclides which could be released to the environment. Only polonium-210, plutonium-238, and hydrogen-3 (tritium) are potential environmental contaminants.

Air monitoring

Mobile air monitoring equipment, mounted on a 1-ton panel truck, for measurement of tritium and collection of particulate alpha-particle emitters was used in the routine monitoring of environmental air within a radius of 20 miles from the laboratory during the collection period. Since the sampling zone is dependent on the wind direction it is possible that air samples from all zones will not be collected during the reporting period.

Airborne polonium and plutonium particulates are collected on Whatman No. 41 filter paper with a high volume air sampler. A 5-cm diameter circle, cut from the center of each filter paper, is processed and analyzed for polonium-210. The remainder of each filter paper is processed and analyzed for plutonium-238.

Airborne tritium oxide is monitored by bubbling air through 100-ml of a liquid scintillation counting solution with p-dioxane as the organic

Table 4. Atmospheric monitoring of polonium-210 Mound Laboratory environs, January–June 1970

Range (miles)	Number of samples	Average concentration[a] (fCi/m³)	Average as percent of AEC standards[b]
0–3 (upwind)	25	11	0.05
0–3 (downwind)	25	8	.04
3–5 (downwind)	25	12	.06
5–10 (downwind)	25	15	.07
10–15 (downwind)	25	14	.07
15–20 (downwind)	25	12	.06

[a] Lowest detectable level (LDL) for polonium-210 in air is 8 fCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 5 fCi/m³ for samples collected 0–3 miles downwind and 15–20 miles downwind. Two LDL's are expressed above for the ranges in which polonium-210 samples are collected. Air is sampled at three locations within the 0–3 and 15–20 mile downwind ranges, and the filter papers are combined to form one composite sample for each range. Air samples in other ranges are comprised of samples collected at the location within each range. Since the volume of air analyzed in the 0–3 and 15–20 mile downwind ranges is 33 percent greater than in the other ranges, the sensitivity expressed as LDL is proportionately lower.
[b] The applicable AEC radiation protection standard for polonium-210 in air is 20 pCi/m³.

Table 5. Atmospheric monitoring of plutonium-238, Mound Laboratory environs, January–June 1970

Range (miles)	Number of samples	Average concentration[a] (fCi/m³)	Average as percent of AEC standards[b]
0–3 (upwind)	24	4.6	0.46
0–3 (downwind)	24	6.5	.65
3–5 (downwind)	24	5.7	.57
5–10 (downwind)	24	4.2	.42
10–15 (downwind)	24	4.0	.40
15–20 (downwind)	24	3.5	.35

[a] Lowest detectable level (LDL) for plutonium-238 in air is 1.3 fCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 0.9 fCi/m³ for samples collected 0–3 miles downwind and 15–20 miles downwind. Two LDL's are expressed above for the ranges in which plutonium-238 samples are collected. Air is sampled at three locations within the 0–3 and 15–20 mile downwind ranges, and the filter papers are combined to form one composite sample for each range. Air samples in other ranges are comprised of samples collected at the location within each range. Since the volume of air analyzed in the 0–3 and 15–20 mile downwind ranges is 33 percent greater than in the other ranges, the sensitivity expressed as LDL is proportionately lower.
[b] The applicable AEC radiation protection standard for plutonium-238 in air is 1 pCi/m³.

Table 6. Atmospheric monitoring of tritium, Mound Laboratory environs, January–June 1970

Range (miles)	Number of samples	Average concentration[a] (pCi/m³)	Average as percent of AEC standards[b]
0–3 (upwind)	25	440	0.22
0–3 (downwind)	25	4,420	2.21
3–5 (downwind)	25	490	.24
5–10 (downwind)	25	340	.17
10–15 (downwind)	25	400	.20
15–20 (downwind)	25	320	.16

[a] Lowest detectable limit for tritium in air is 200 pCi/m³.
[b] The applicable AEC radiation protection standard for tritium in air is 200 nCi/m³.

[3] Summarized from "Environmental Monitoring Report, January-June 1970" (MLM–1784).

Table 7. Offsite water monitoring for radioactivity, Mound Laboratory environs, January-June 1970

Sampling location[a]	Number of samples	Polonium-210[b] (pCi/liter)		Plutonium-238[b] (pCi/liter)		Tritium[b] (hydrogen-3) (nCi/liter)	
		Average[c]	Percent of concentration limit	Average[c]	Percent of concentration limit	Average[c]	Percent of concentration limit
1	24	1.90	0.27	14.2	0.28	546.0	18.20
2	23	ND	ND	5.3	.11	14.0	.47
3	23	93.0	13.28	39.1	.78	336.0	11.20
4	23	4.70	.67	11.8	.24	15.0	.50
5	23	ND	ND	11.1	.22	15.0	.50
6	23	ND	ND	11.6	.23	12.0	.40
7	23	ND	ND	11.4	.23	12.0	.40
8	23	ND	ND	5.0	.10	14.0	.47
9	24	ND	ND	4.6	.09	16.0	.53

[a] See figure 2 for number of sampling locations. Sampling location and description: 1-Drainage ditch, 2-Upstream from laboratory, 3-Laboratory effluent, 4-250 yards downstream from location 3, 5-Chautauqua Road Bridge, 6-Chautauqua Dam, 7-Franklin, Ohio, 8-Pond, opposite V.A. hospital, Dayton, Ohio, 8 miles NE of Mound Laboratory; and 9-Pond, Possum Creek Reserve, Dayton, Ohio, 6 miles NE of Mound Laboratory.

[b] Lowest detectable level for polonium-210 in water is 1.80 pCi/liter. Lowest detectable level for plutonium-238 in water is 4.5 pCi/liter. Lowest detectable level for tritium in water is 6 nCi/liter.

[c] The applicable AEC radiation protection standards for uncontrolled areas are as follows:
Polonium-210 in water: 700 pCi/liter
Plutonium-238 in water: 5 nCi/liter
Tritium in water: 3 μCi/liter
ND, less than the lowest detectable limit.

solvent. A 20-ml aliquot of the resulting solution is counted directly in a liquid spectrometer for 10 minutes. The analysis is directed to tritium oxide rather than the gas because the AEC standard for the oxide is 200 times more restrictive than for the gas.

The results of the airborne monitoring program are presented in tables 4, 5, and 6. The average concentrations of polonium-210, plutonium-238 and tritium in the environment are below the AEC radiation protection standards.

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed separately to reduce the concentrations of these radionuclides to a level at which they may be discharged to the environment. Treated polonium liquid waste is discharged to the Great Miami River via a closed sewer line which also carries the treated plant sewage. The treated plutonium waste is discharged to a drainage ditch which runs through the plant site and eventually reaches the river.

Helium-3 being purified at the Mound Laboratory contains small quantities of tritium. In addition, tritium is recovered from various AEC tritium-contaminated wastes. Liquid waste generated by these operations is treated (diluted with water when necessary) and discharged to the same drainage ditch as plu-

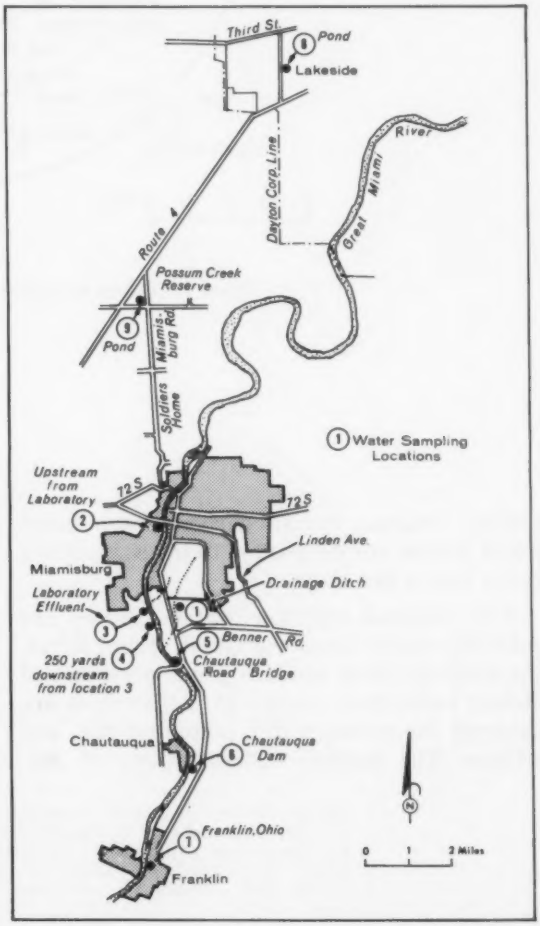

Figure 2. Water sampling locations, Mound Laboratory

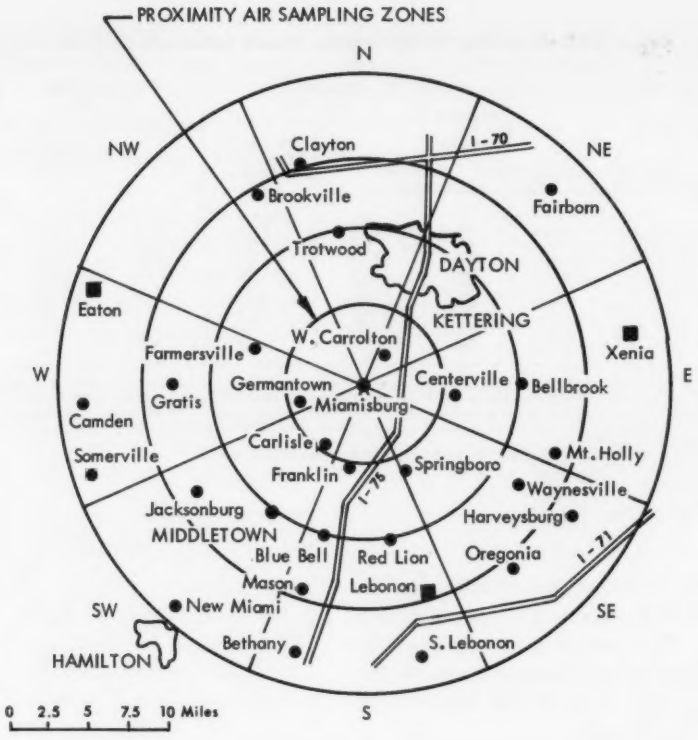

Figure 3. Offsite air sampling zones, Mound Laboratory

tonium waste. Some tritium-contaminated liquid wastes are discharged to the same closed sewer line as polonium.

Two hundred milliliter water samples are collected weekly from the Great Miami River, the drainage ditch and two ponds northeast of Mound Laboratory (figure 2). All samples are analyzed for polonium-210, plutonium-238, and tritium. The average concentrations of plutonium and tritium in water discharged to the environment were well below the AEC radiation protection standards. Average concentrations of tritium, polonium-210, and plutonium-238 are given in table 7 for January-June 1970.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July-December 1969	December 1970

Reported Nuclear Detonations, December 1972

(Includes seismic signals presumably from foreign nuclear detonations)

The U.S. Atomic Energy Commission announced that the United States recorded two sets of seismic signals, presumably from Soviet underground nuclear explosions. The signals originated at approximately 11:30 p.m. EST, December 9, 1972, and followed one another closely. Both sets of signals came from the Semipalatinsk nuclear test area. The first set was equivalent to those of an underground nuclear explosion in the yield range of 20–200 kilotons, and the second set was equivalent to the yield range of 200 kilotons—1 megaton.

The U.S. Atomic Energy Commission announced only one nuclear detonation for December 1972. An underground nuclear test with a yield range of 20 to 200 kilotons was conducted December 21, 1972 at the Nevada Test Site.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

TECHNOLOGY ASSESSMENT OF RISK REDUCTION EFFECTIVENESS OF WASTE TREATMENT SYSTEMS FOR LIGHT-WATER REACTORS. *J. E. Martin, F. L. Galpin,* and *T. W. Fowler. Radiation Data and Reports, Vol. 14,* January 1973, pp. 1–8.

The Environmental Protection Agency (EPA) routinely performs technology assessment of applications of nuclear energy that have the potential to introduce radioactive material into the environment. The Agency has extensively examined the performance of waste treatment systems for light water power reactors as a function of cost with regard to an examination of bases for environmental radiation standards and for EPA review of environmental impact statements for such plants. It was determined that significant and cost effective offsite dose reductions from gaseous discharges could be brought about by using available technology to holdup the gases until essentially krypton-85 remained; further dose reductions by cryogenic removal of krypton-85 did not appear to be justified in view of the costs involved. Similarly for liquid wastes, reasonable technology appears to stop just short of recycling waste streams to contain tritium.

KEYWORDS: Air, cost, light-water reactors, waste treatment, water.

ASSESSMENT OF THYROID INHALATION DOSES IN THE WESTERN UNITED STATES FROM THE CHINESE NUCLEAR TEST OF NOVEMBER 1971 *R. B. Evans, R. N. Snelling,* and *F. N. Buck. Radiation Data and Reports, Vol. 14,* January 1973, pp. 9–16.

Following a nuclear detonation by the People's Republic of China measurable increases of radioactivity were detected over the western United States by the Air Surveillance Network which is operated by the National Environmental Research Center-Las Vegas. The progress and intensity of the radioactive cloud across the United States is presented graphically. The highest hypothetical infant thyroid dose equivalent calculated to result from the inhalation of iodine-131 and tellurium-132 was 0.2 mrem at Scotty's Junction, Nev.

KEYWORDS: Airborne radioactivity, China, doses, iodine-131, nuclear detonation, tellurium-132, thyroid, western United States.

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